

herbarium essentials

THE SOUTHERN AFRICAN HERBARIUM USER MANUAL



by Janine Victor, Marinda Koekemoer, Lyn Fish,
Shirley Smithies & Marthina Mössmer



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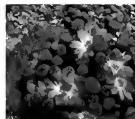
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Collections made during an expedition in the field.





introduction

...from Africa—for Africa

Many plant species are threatened with extinction through human activity. Southern Africa has over 30,000 species of flowering plants and ferns, but is poorly equipped to monitor and evaluate this heritage. We believe that establishing, expanding, and improving herbaria is the first and most important step towards achieving this objective.

Herbarium Essentials is an illustrated, Afrocentric manual for herbarium workers, supplying the basic information about a functional herbarium. It provides a theoretical background, as well as comprehensive methods for running a herbarium, taking its different aspects into account. These aspects include plant collecting, mounting, scientific and physical curation, as well as computerisation. The combination of theory and practical expertise will equip you with the essential knowledge required to work in and run a herbarium.

We hope that this book will serve as a valuable resource and guide for all herbarium professionals in southern Africa and further afield.

Tournefort first used the term "herbarium" to describe a collection of dried plants in 1700. Later, Linnaeus took up the term and it has been used in this context ever since. A herbarium is a collection of dried plant specimens arranged in an accessible system. It is an important source of data used by researchers in many plant-related sciences and is most often used for

taxonomic research. Herbaria are centres where plant taxa are studied. This includes identification (how they are recognised), nomenclature (the naming of specimens to avoid the problem of ambiguity), classification (grouping of plants with similar properties), distribution (where it grows), ecology (the kind of habitat), and use (useful properties). They are funded by national or local governments, universities, private institutions, research organisations, scientific societies, or individuals, and differ vastly in size and main function.

Herbaria of the world

The largest herbaria in the world are all in the northern hemisphere. These herbaria are all far larger than any of the herbaria in the southern hemisphere. In Africa, only one herbarium (PRE) houses over a million specimens.

Smith, Willis & Mössmer (1999) have compiled the most comprehensive survey of southern African herbaria. The survey shows that most of the larger herbaria in the subcontinent are in South Africa.

Functions of herbaria

Herbaria have one or more of the following functions or roles:

- Conservatory of dried plant material
- Archival record of a region's flora
- Source of botanical information and diversity



Staff working in a herbarium.

Largest herbaria in the world

Herbarium (ACRONYM)	Country	Number of specimens
Paris (P, PC)	France	8,877,300
Kew (K)	United Kingdom	6,000,000
Leningrad (LE)	USSR	5,770,000
Stockholm (S)	Sweden	5,600,000
New York (NY)	U.S.A.	5,300,000
British Museum (BM)	U.K.	5,200,000
Genève (G)	Switzerland	5,000,000
Harvard University (A, AMES, ECON, FH, GH, NEBC)	U.S.A.	4,858,000
Smithsonian (US, USNC)	U.S.A.	4,368,000
Montpellier (MPU)	France	4,000,000

Source: Holmgren et al. 1990

Largest herbaria in the southern hemisphere

Herbarium (ACRONYM)	Country	Number of specimens
Bogor (BO)	Java	1,600,000
Pretoria (PRE)	South Africa	1,200,000
Sydney (NSW)	Australia	1,000,000
Melbourne (MEL)	Australia	1,000,000
Adelaide (AD)	Australia	700,000
Wellington (CHR)	New Zealand	600,000
Indooroopilly (BRI)	Australia	523,500
Canberra (CANB)	Australia	500,000
Nairobi (EA)	Kenya	500,000
Rio de Janeiro (R)	Brazil	500,000

Source: Holmgren et al. 1990

Largest herbaria in southern Africa

Herbarium (ACRONYM)	Country	Number of specimens
Pretoria (PRE)	South Africa	1,200,000
Harare (SRGH)	Zimbabwe	513,700
Compton (NBG & SAM)	South Africa	507,000
Bolus (BOL)	South Africa	335,500
Grahamstown (GRA)	South Africa	200,800
Natal University (NU)	South Africa	120,000
Wits University (J)	South Africa	100,000
Natal (NH)	South Africa	100,000
Schweickerdt (PRU)	South Africa	100,000
Malawi (MAL)	Malawi	84,000

Based on Smith, Willis & Mössmer 1999

- Recorder of plant names
- Supplier of a support service to the community: plant identification, information, education, collecting services for bio-prospecting or other specialised projects
- Training for botanists
- Research

Different types of herbaria

We can identify many different types of herbaria, based on the kinds of specimens they house.

- **International** herbaria keep specimens from all over the world.
- **National** herbaria keep specimens from all regions within a specific country.
- **Regional** herbaria keep specimens from a specified region or province within a country.
- **Local** herbaria keep specimens from a small area within a region or province.
- **Teaching or academic** herbaria are attached to a training institute and are generally a place where students deposit their collections.
- **Private** herbaria are kept by individuals, or are attached to private land, such as farms or private nature reserves.
- **Research** herbaria usually house voucher specimens representing one of the following:
 - A specific research field, for example, medicinal plants, weeds, or useful plants
 - A distinct family, for example, Fabaceae or Asteraceae
 - A specialised plant group, for example, water plants or bryophytes

Specialised collections within herbaria

There can also be special collections within a single herbarium.

- **Historic:** Very old collections that are kept separate and in their original state, for example, the South African Museum (SAM) collection in Compton Herbarium, (NBG), Cape Town. Cupboards and covers are unchanged and often not curated; for example, name changes are not incorporated.
- **Vouchers:** Voucher specimens for ecological, anatomical, cytological, chemical, or molecular studies.
- **Special Interest:** Groups of plants with a linking quality, for example, medicinal plants. ▲



How this book is arranged

CHAPTER 1 discusses the different **types of collections** a herbarium contains and also briefly describe the different ways in which collections are expanded.

CHAPTER 2 gives a detailed account of **plant collecting**; including the equipment you need for collecting, what to collect, how to collect, and how to record information in the field.

CHAPTER 3 illustrates how to go about **pressing and drying** your specimens. We describe, in detail, standard as well as special pressing methods.

CHAPTER 4 explains why specimens are mounted, describe the materials and equipment you need, and illustrate various **mounting** procedures.

CHAPTER 5 discusses the different aspects of **physical curation**—storing, labelling, filing, and repairing specimens; making indexes, cupboard lists, and quick guides; handling loans and duplicates; and computerising the collections.

CHAPTER 6 evaluates methods for the prevention and treatment of **herbarium pests**.

CHAPTER 7 describes **scientific curation** of the herbarium collections, with emphasis on taxonomy and nomenclature, identifying specimens, and incorporating new research.

CHAPTER 8 summarises the essential procedures for setting up a **new herbarium**, from determining the basic needs of your herbarium, to herbarium management.

APPENDIX 1 lists local and international suppliers of herbarium materials.

APPENDIX 2 shows a typical field label.

The comprehensive **INDEX** will help you find the information you need.



CHAPTER 1

herbarium collections

Creating a balance between the use, management, and conservation of collections is a significant challenge.

—Williams & Cato, 1995

To a large extent, a herbarium consists of its collections of preserved plant specimens. This chapter discusses the different types of collections and how they are established and maintained, as well as ways in which a herbarium increases its collections.

In addition to the main collection of pressed, mounted specimens, a herbarium can contain collections of fruits and seeds, bulky specimens, wood samples, bryophytes, fungi, fossils, and plant material stored in preservatives. Illustrations, photographs, and copies of specimens, as well as microscope slides, also form part of the herbarium's collections.

Types of collections

Angiosperms are usually pressed and then stored dried and mounted on sheets of card. These specimens are stacked on top of each other and stored on shelves in cupboards. Some plants or organisms, however, cannot be mounted and stored in this way. Apart from the main collection, there are therefore a number of ancillary collections containing fossils, fungi, lichens, and bryophytes. Seeds, fruits, and wood are also stored for taxonomic purposes. Sometimes specimens are stored in liquid chemicals in glass bottles. These ancillary collections are usually housed separately, requiring the herbarium collections to be divided spatially.

Main collection

The main collection, consisting of angiosperms and pteridophytes, may or may not include cultivated plants and gymnosperms; in some herbaria either or both are housed separately. Herbarium staff, staff from other local institutes, and individuals collect most of the specimens incorporated into the main herbarium collection. Some specimens are gifts, or are gained from an exchange system with other herbaria. Specimens that have been used for research purposes (for example, anatomical or ecological studies) are deposited in herbaria by the researchers for future reference. They are termed voucher specimens.

TIP A more detailed discussion on how to collect, press, mount, and archive plant species follows in Chapters 2, 3, and 4



A plant specimen, pressed, dried, and mounted for storage in a herbarium.

Carpological collection

A carpological collection consists of cones, fruits, or seeds and is housed separately. Each is cross-referenced with the corresponding herbarium sheet.

Exceptionally large specimens, for example, cycad cones, are best kept in boxes. The best boxes are made from cloth-covered hardboard. Their design should have a drop-flap front as well as a lid-top. The collector's label should be glued to the outside of the box, or the box can have a label-holding slot. In tropical herbaria it may be better to house specimens in metal boxes, as these are more insect-proof. Seeds and fruit, stored in the herbarium for taxonomic purposes, are kept in boxes or bottles in metal filing cupboards with shallow drawers. It is vital that seed is kept dry to prevent germination. Fleshy fruit can also be kept as spirit material. (See "Spirit collection".)

All seeds must have a voucher specimen in the main collection; otherwise, they are worthless for scientific research.

Seeds may be stored for future cultivation or re-introduction for conservation purposes, in which case, special conditions are needed to maintain their viability. For short-term storage (days, weeks, or months), seeds may be kept at 5°C (in a normal refrigerator) in an airtight container with silica crystals to absorb moisture. Long-term storage (longer than one year) requires seeds to be stored at -20°C to -5°C. Stored seeds should not be exposed to warmth or moisture, or they will germinate or become non-viable.

Bulky specimens

Bulky plant parts, such as palm fronds, can be stored in archival folders or drop front boxes with a label glued to the outside.

Xylarium

A collection comprising only wood specimens is known as a xylarium. Wood can be stored for two main purposes: one is to provide samples from which sections may be taken for anatomical studies; another is to provide information about the trees for purposes of identification or description. Blocks of wood can



Wood specimens.

have one side polished and the other side unpolished, and it is useful to have a bit of bark attached. The blocks can be stored in cupboards or drawers. The easiest way to store wood is to catalogue the blocks and file them in numerical sequence.

For every wood specimen, there must be a corresponding voucher specimen in the main collection. Each block should have a catalogue number written on it and this number must be written on the herbarium sheet on which the voucher specimen is mounted. Without this cross-reference, the wood collection is of no value.

If no separate wood collection is available, small pieces of wood can be mounted on herbarium sheets.

Bryophytes and lichens

Bryophytes and lichens are not mounted on cardboard sheets like other plants—they are kept in folded envelopes. (For more information on collecting and drying bryophyte specimens, see "Bryophytes", and "Drying specimens". For more information on storing bryophytes and making envelopes, see "Storing bryophytes and lichens").

Macrofungi

Macrofungi should be stored whole or sliced lengthwise. Spore prints and drawings of microstructures should be stored with the specimens. Fungi are particularly susceptible to insect attack and should be disinfected thoroughly before storage.

Store fungi in one of the following ways:

- In sealed polythene bags, with a few crystals of silica gel to keep the specimen dry.
- In a desiccator over calcium chloride.
- In small cardboard boxes containing silica gel if the specimen is particularly fragile.

Fossils

Fossils are usually large and bulky and are best kept in metal

filling cupboards; specially designed cupboards with shallow drawers with adjustable spacing are ideal. The drawers should be lined with a thin layer of foam rubber. Each fossil should have a small label with a catalogue number attached to it. The collection information can now be recorded in a book, or on the computer. If the fossil is very small, it can be mounted either on card, or on a larger piece of rock from the same locality. The rocks can be kept in stratigraphic order and within that, locality order. Within each locality, the specimens can be ordered taxonomically. Alternatively, the fossils can be ordered by organ type.

Spirit collection

Very fleshy or delicate structures or complex flowers, such as those of the Asclepiadoideae, are stored in liquid chemicals or "spirits". The advantage of this method of storage is that the three-dimensional shape of the specimen is maintained. Plant material preserved in this way can be used for anatomical research and for taking measurements of features that shrink when the plant material is dried. Specimens are usually fixed to prevent their anatomical distortion, and then stored in jars with preserving liquid, for example, alcohol or Industrial Methylated Spirits (IMS). For more information, see "Fixatives".

Illustrations, photographs, and copies of specimens

Illustrations or photographs are useful in providing a permanent record of the habit, habitat, and colours of the plant. Prints or slides can be used in publications and lectures. They may prove to be of great value if they depict habitats as they were before being destroyed, or species as they were before becoming extinct.

Photographs, photocopies, or scanned images may also record specimens from other herbaria, such as types, historical specimens, new taxa, or taxa not represented in the collections.

Illustrations and photographs should be mounted on standard herbarium sheets. Each print or slide should be labelled with the collection information: name, locality, collector's name and number, date, and so on.

Photographic work emanating from research, such as anatomical, cytological, or SEM (scanning electron microscope) studies, may be kept with the voucher specimens. They can be kept together in a zip-closure plastic bag. Negatives should be kept separately and cross-referenced.

Photographs can be filed in the main collection; if corrosive sublimate is used for fumigation however, photographs should be kept elsewhere.

Slides and negatives can be kept in special holders and filed in a filing cupboard with cross-references to herbarium specimens where relevant.

Microscope slides

Slides with sections, such as anatomy, pollen, or other preparations for microscopic examination, are kept in a special cupboard with drawers made to hold them. They may be numbered serially and the serial number placed on the corresponding herbarium sheet. Alternatively, collectors' numbers may be used.

Expanding the collections

Specimens covering a wide range of habitats of the taxon's distribution range and variability will provide more information on the relationships of taxa. Collections are expanded in several ways.

Plant collecting

Collecting is the most obvious way of expanding a herbarium collection. Anyone with the necessary permit may collect plants and donate them to a herbarium. Keep in mind that there are specific guidelines on how plants should be collected, pressed, and dried to be of high enough quality to be stored as an archival record. For more information, see "Collecting Plants" and "Pressing and Drying".

When staff members spend a lot of time in the field making collections, these usually form the main body of research material. Field trips, however, are costly and time-consuming and herbaria often have to rely on other methods for obtaining specimens. Collectors should be encouraged to collect duplicate specimens. In this way, the extra sets may be used for exchange, which is another way of expanding the collection.

Gifts

Herbaria may donate duplicate specimens to other herbaria. Gifts of herbarium specimens may either be given freely, or donated in exchange for identifications. This makes the information on the plants generally available and the results of study and identification are disseminated in a permanently available form. Individuals may also donate unidentified specimens to herbaria and, in return, the herbarium will provide them with names. Gifts are incorporated into the herbarium, provided the specimens and labels are of a high enough quality.

Should an employee of one herbarium go on a collecting trip to a region covered by another herbarium, it is good etiquette to collect and donate duplicate specimens to the herbarium in the region. Sometimes one of the conditions attached to the issuing

of a collecting permit, is that the herbarium of the region receives duplicate copies of all specimens collected in that region. Gifts of sets of specimens from investigations or explorations by botanists with no herbarium affiliations are frequent. Botanists will be encouraged to give sets of specimens to herbaria that have a reputation for active research and an interest in increasing the collections, particularly if a policy is in place that ensures that material will be kept, cared for, and accessible.

Deposits

The difference between a gift and a deposit of material is that, in accepting material on deposit, the herbarium is obliged to keep the specimens in the collection. The herbarium cannot discard them or send them out on exchange. Valuable specimens that serve as vouchers for published records, for example, drug plant investigations, ecological work, or legal evidence, are often received under such conditions. Voucher specimens are frequently very carefully made and often carry valuable information that is not ordinarily available. Every effort should be made to encourage such deposits, especially as they are likely to stimulate the interest of non-taxonomic botanists and other scientists in the herbarium.

Exchanges

Herbaria may have exchange systems with one another—for every specimen donated by one, the other donates a specimen in return. The material sent for exchange should be of such quality that the receiving herbarium is happy to incorporate it into its collection. Herbaria involved in exchange systems may put in requests for certain taxa or regions. If this is the case, consider these requests when sorting duplicates.

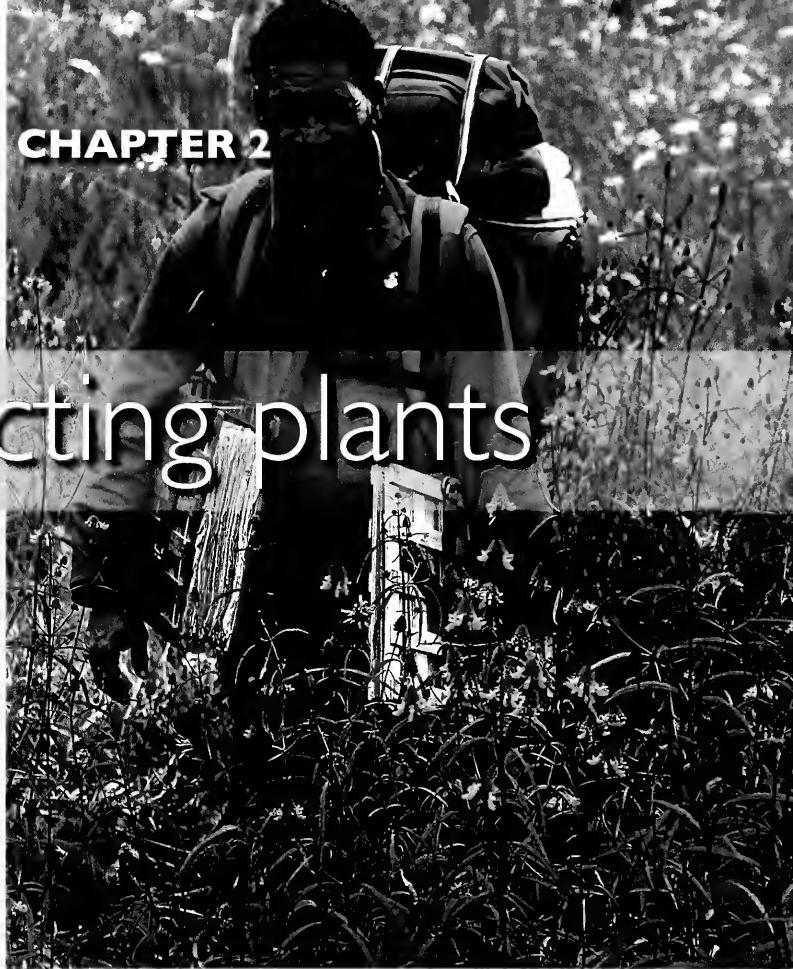
Exchange policies should retain sufficient flexibility to ensure that material is sent where it would be of most value, regardless of that institution's exchange "credit". Herbaria with a policy for saving space may encourage duplicate specimens to go elsewhere. ▲



Fossils can be stored in metal cupboards with shallow drawers.

CHAPTER 2

collecting plants



*Where have all the flowers gone?
Gone to cupboards, every one!*

Herbarium specimens are resources that can provide a large amount of information on plant taxa, as well as on the flora and vegetation of a region. The quality of the specimens determines the scientific value of the collection, and collecting good specimens is the first step in preparing specimens of a high standard.

Collectors

Usually, the herbarium staff collects most of the material housed in the herbarium. In addition, the role played by outside collectors is of great importance to the development of a herbarium. Owing to budget constraints and the extensive geographical region that often has to be covered, herbarium staff usually cannot collect with the intensity needed for comprehensive coverage of a particular floral area. To be cost-effective, herbarium workers tend to collect only during a prime season (after good rains, for example), or when the most species are known to be flowering.

All collectors should be encouraged and trained to collect and prepare plant specimens of good quality, accompanied by properly completed labels. In this way, the herbarium obtains the maximum scientific information from each specimen.

Professionals

Professionals work at institutions—for example, universities, technikons, or research organisations—in fields related to plant taxonomy, such as nature conservation, landscaping, ecological surveys, or weed control. Some of these institutions may have their own herbaria; otherwise, they rely on national or provincial herbaria.

Amateur collectors and parataxonomists

Amateur botanists should be encouraged to send collections to the herbarium. They can make a significant contribution by collecting rare and interesting plants, in different seasons, or from unusual locations. Staff can cooperate with amateurs, providing them with the information they need in return for donated specimens.



This specimen was collected in 1862, but is still in very good condition because it was well preserved.

Students

Many educational institutions require their students to collect herbarium specimens as part of their coursework.

Types of collecting

Collecting plants differs from person to person and depends on the aims of the collector:

Research or specialised collecting
Collecting for taxonomic research projects concentrates on specific plant groups and is usually confined to plants within a specific family, genus, or species. Collection of voucher specimens for cytological or anatomical projects also falls into this category. It is important to prepare voucher specimens of good quality to ensure that the identity of the subject of the research can always be verified.

Researchers studying other aspects of the environment, for example, weeds for herbicide trials or vegetation studies, also collect plant species. Accurate plant names and voucher specimens are important for such projects.

Floristic collecting

Floristic collecting entails collecting all plant species in a certain area. Such areas include regions poorly represented in a specific herbarium, or areas where an unusual event has occurred (for example, fire after many years of fire protection, or unusually heavy rains). It could be an area of specific interest, for example, a nature reserve or specific geological formation. If the aim of a collecting trip is floristic collecting, planning is essential to avoid collecting in well-collected areas, while under-collected areas remain neglected.

What you need

Before you start collecting plants, you need permission to collect, as well as the right equipment, maps, vehicles, and emergency supplies. This section describes all of these prerequisites in detail.

vehicle equipment



storage boxes



Jerry cans



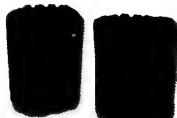
storage boxes



water can



high-lift jack



sand tracks



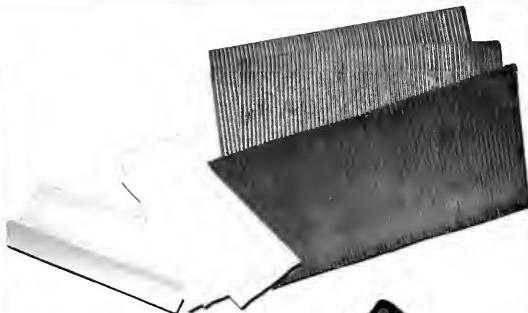
Tip Find out which spare parts are essential from the dealer who services your vehicle.

Additional equipment

- First aid kit
- Axe
- Spade
- Fire extinguisher
- Jumper cables
- Puncture repair kit
- Tow rope
- Fuel filter
- Brake fluid
- Fuses
- Insulation tape
- Light bulbs
- Spark plugs
- Electrical wire, 5 m length
- Fan belt
- Funnel
- Glue, epoxy or quick-set adhesive
- Shock absorbers, set
- Tyre pressure gauge



collecting equipment



Plant presses, flimsies, drying paper, corrugated cardboard sheets.



prospecting or geological hammer



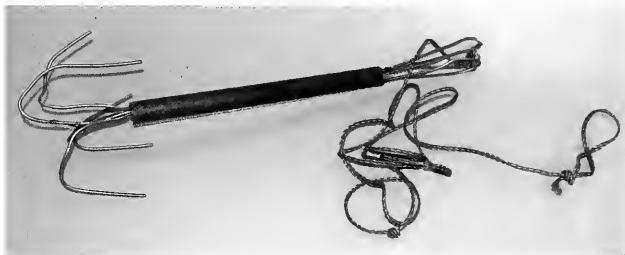
secateurs



tree loppers



small knife for lifting bryophytes off their substrate



Aquatic plant rake.

- Tissue paper and newspaper for bryophytes, fungi, and delicate flowers.
- Gummed cards for delicate flowers.
- GPS (Global Positioning System) instrument.
- Topographical, geological, and vegetation maps of the area concerned.
- Pencil or waterproof pen.
- One large plastic bag (approximately 550 x 850 mm) per collector, in which to put small bags of plants.



An assortment of plastic bags in which to put plants.



Brightly coloured paint or cards on collecting tools help locate them when lost.

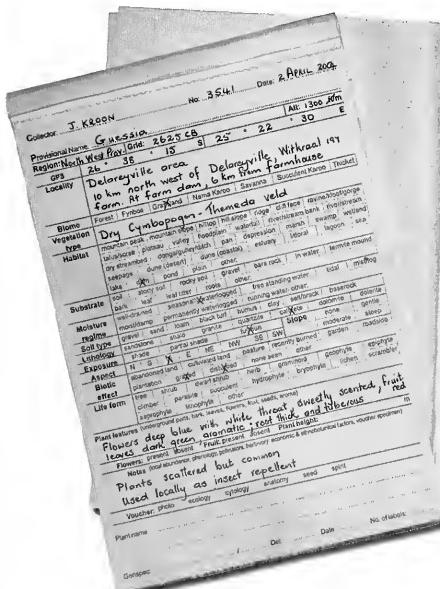
collecting equipment



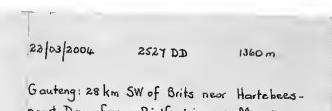
Hand lens of 10 \times magnification.



Leak-proof plastic bottles with preserving liquid or fixative if required for cytological, palynological, or anatomical studies.



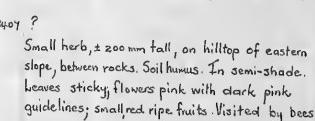
Collector's register, or printed herbarium field labels. (A blank field label to photocopy is included on page 82.)



3405 ?
Small shrub, up to 1.5 m tall, much branched, growing near stream; leaves light green; flowers red, smelling cinnamon. Only a few plants seen.



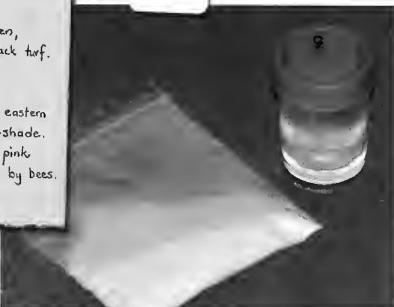
3406 ? Eragrostis
Densely tufted, leaves flat, dark green, ± 600 mm tall, common in valley, in black turf.



3407 ?
Small herb, ± 200 mm tall, on hilltop of eastern slope, between rocks. Soil humus. In semi-shade. Leaves sticky; flowers pink with dark pink guidelines; small, red ripe fruits. Visited by bees.



Jeweller's tags for collector's name and number.



Silica gel to dry samples quickly if required for DNA studies.

Collecting permits

Most southern African countries are signatories to the International Convention on Biological Diversity. It is advisable to be aware of the laws applicable to a certain area before collecting and to obtain the necessary permits. The ordinances or requirements for permits may vary from country to country, or within different provinces of a country. In South Africa, for example, permits are needed even for unprotected taxa, and special permission is required for threatened and protected taxa.

You can usually obtain permits from government departments in charge of the environment or indigenous plant control. Even with the necessary permit, you should still make prior arrangements with the local officers responsible for the area in which you want to collect. It is advisable to apply for a permit well in advance, as it may take several months to process.

Follow these general guidelines:

- Do not collect or transport any plants without a collecting permit.
- In addition to the permit, obtain the consent of the land-owner before collecting any plants on private property.
- Additional permits are usually required for collecting in provincial nature reserves, municipal or private nature reserves, national parks, forestry areas, and game reserves.

Special permits

- **Phytosanitary Permits** may be needed when transporting plants across borders of some countries. They must be obtained from the country of origin.
- **CITES** (Convention on International Trade in Endangered Species) legislation regulates and controls the international trade in material obtained from plants considered to be endangered. Scientific material is not exempt from it. For the movement of CITES-listed material, you need both a CITES export permit from the source country and a CITES import permit from the relevant conservation authority.

Vehicle maintenance

It is very important to keep the maintenance of the collecting vehicle up to date; this reduces the chances of a serious breakdown occurring in the field.

Emergency supplies

- First aid kit containing such basics as bandages, splints, antiseptic solutions, pain killers, antihistamines, an anti-emetic for nausea, an anti-spasmodic for diarrhoea, rehydration



Gathering plant material in the field.



Pressing plants in the field.



Adiantum reniforme, a fern, prepared for pressing.

- powder, water purifying tablets, and burn ointment.
- Enough water should be available for drinking to prevent dehydration, for washing hands, especially if dealing with poisonous plants, and for the vehicle.
- Each member of the collecting team should carry a box of matches to light a fire. In the event of them getting lost, it will enable them to produce a smoke signal or keep warm.
- Guide to snake identification.

TIP

Knowing how to give cardiac-pulmonary resuscitation (CPR) and how to deal with snakebite is important. A basic knowledge of first aid could be life saving, especially when you are collecting in remote areas. Contact an organisation that presents first aid courses in your area for more information.

Maps and map reading

Maps come in different scales: 1:1,000,000; 1:500,000; 1:250,000; 1:50,000 covering areas the size of the country to the size of a quarter degree. Select the best scale map for your needs.

The coordinate reading is always taken from the top left corner of the grid. The line of latitude is always the first coordinate, and refers to the number of degrees north or south of the equator. Because southern African countries are south of the equator, their position will always be plotted as number of degrees "S". The line of longitude indicates the position of any given point to the east or west of the Greenwich Meridian, which is at 0° and is thus indicated as "E" or "W". In the southern parts of Africa it will always be "E", given the fact that we are east of the Greenwich Meridian.

Every map has lines of longitude and latitude, and is named according to the intersection of these lines in the top left corner of the map. The uppermost line of latitude and the line of longitude on the left edge of the map are the two reference lines. The reading is given at the point where these lines cross. At this point, the degrees are indicated. These lines of latitude and longitude representing the degrees may be divided further. Each degree is divided into 60 minutes (60') and each minute into 60 seconds (60"). If the reference point is halfway between the

TIP

To make ordinary matches waterproof, keep matches and the striking surface of a matchbox in a film canister; or dip the match-heads in melted candle wax (remove the wax just before striking the match).

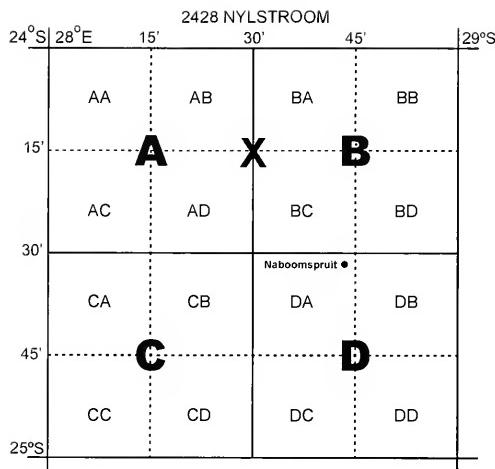
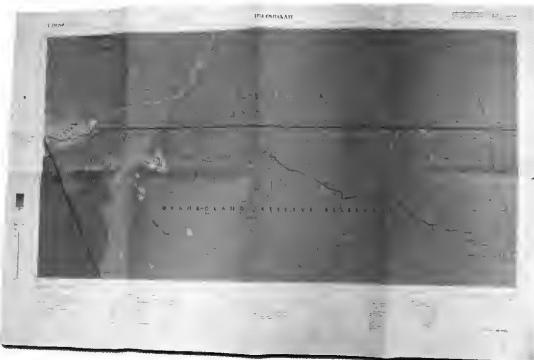


Diagram to work out quarter-degree grid references using lines of latitude and longitude.

lines of longitude in the diagram, at X, then it is at 30 minutes (30') and 0 seconds (0") past 28°E. X also lies 15 minutes south of the line of latitude. The position of X is therefore 24°15'0"S; 28°30'0"E.

Quarter-degree grid readings are often used to provide broad locality details on labels; for instance, the town Naboomspruit lies at 2428DA.



A 1:100,000 map.

Global Positioning Systems

If you are planning fieldwork in a region where there are no roads, a GPS (Global Positioning System) instrument is essen-

tial for orientation. The GPS gives latitude and longitude readings accurate to within a few metres. A GPS reading is an excellent way of obtaining an accurate locality of the plants collected, and should therefore be recorded on the specimen label.



A GPS and a map.

What to collect

The importance of collecting good plant specimens cannot be over-emphasised: good specimens are a prerequisite for accurate identifications and for adding value to a herbarium collection.

- Collect only plants in flower or fruit (both if possible), as most often the characters traditionally used for identification in the herbarium are found in these organs.
- Make specimens large enough to present a fair sample of the plant, its manner of growth, branching, and so on.
- Where possible, collect the entire plant: a good specimen comprises all the organs—underground parts, stems, leaves, flowers, and fruits. Basal parts of grasses, sedges, ferns, and bulbous plants are essential for identification.
- When collecting large plants, such as trees, shrubs, and large herbs, representative parts should be collected. Show the complete range of variation that is present by collecting mature and immature parts, lower and upper leaves, buds, and coppice shoots.
- Specimens too large for the mounting sheet can be bent, broken, or cut before they are pressed. Large or complex parts, such as fern fronds or cycad leaves, are collected only in part. The base, middle, and apex are usually adequate for most taxa.
- Many plants develop leaves and flowers at different times. Each separate stage can be collected independently and pressed as it appears. Great care must be taken to collect leaves and flowers from the same plant. (Note that different collector's numbers should be used.) Large plants such as trees and shrubs are generally marked *in situ*, while smaller

plants may be collected and cultivated.

- The identification of many plant groups depends on characters other than flowers and fruits. Find out which characters are important for various families or genera (see Fish 1999).
- Valuable information can be obtained by collecting the same species in different habitats, at different localities, and in different seasons (under different collector's numbers).
- Do not collect only the smallest individuals of a species merely because they will fit on a herbarium sheet or dry easily. Select individuals of average size. If possible, a number of plants should be collected to show the morphological variation within the population (size, for example). Enough samples of the specimen should be collected to fill a herbarium sheet; extra flowers are often particularly useful.
- Collect a number of duplicates. Duplicate specimens provide material for exchange or gifts to other herbaria and ensure that collections are not lost entirely, should a sheet be mislaid or damaged in one herbarium. This is especially important if a collection is later designated as a type specimen.
- Do not always be deterred from gathering what appears to be material belonging to a species already collected; it may prove to be different from the one with which you initially associated it.
- Weeds should be collected, as information gained from such material, for example, distribution records, possible introduction data and rate of invasion, could help with control.
- Although entire plants and duplicates should be collected, discretion must be used, especially if the plant appears



Plant material ready to be pressed.

to be rare. Where possible, collect at least one complete plant specimen to show the basal parts and roots, and one duplicate specimen that can be deposited in another herbarium. Should anything happen to the first specimen; a duplicate is available elsewhere.

Dealing with collected material in the field

When you have obtained suitable material, your next task is to deal with the specimens from the point of collection to the stage where they are placed in a permanent press. The ideal is to press material immediately.

If, however, there is insufficient time to press the specimens in the field, or if the collecting site is difficult to reach carrying presses, you can place specimens in plastic bags and press them later. Place each specimen in a small plastic bag, add a few drops of water if possible, and close the bag tightly. Placing each specimen in a separate bag saves time when pressing; there is less damage to the specimens, and flowers or fruits that may have dropped off are preserved. Therefore, collect into separate bags even if plants are too large for the bags to close. To make it easier to carry the small bags, place them in a single large plastic bag. Do not use the plastic bag method for specimens that are delicate or wilt easily. For such plants, a field press is necessary. A field press is lightweight and is closed by expandable straps. It has a device for carrying it around easily in the field. Some collectors prefer to collect directly into a field press rather than using plastic bags.



A field press.



A lightweight, temporary alternative to a field press is an A4-size notebook.

Bryophytes and lichens

Bryophyte and lichen collecting procedures are different from the standard collecting methods. Bryophytes, fungi, and lichens should not be pressed, as pressing distorts the form of the plants and destroys some of the critical morphological features. Van Rooy (1998, 1999) provides very good notes on collecting and preserving bryophytes (liverworts and mosses); these methods also apply to lichens.

How to collect bryophytes and lichens

1. Lift the specimen from the substrate by hand or with a knife, taking care to include the layer of soil or bark underneath the plant.
 - Collect lichens that grow on rocks from which they are difficult to remove by chipping off a piece of the rock with a hammer and chisel, or a geological pick.
 - Collect lichens on tree bark with the bark; then cut the specimen to size to fit in an envelope. (See "Envelopes" for instructions on folding your own envelopes.)
2. Place the specimen carefully into a brown paper bag.
 - Aquatic bryophytes (for example, species of the peat moss genus *Sphagnum*) hold large quantities of water; squeeze the water out before placing the specimen in the bag.
3. When the specimen is dry, remove the excess soil from the dried plant with a sieve, and place the specimen in an envelope.
4. Wrap terrestrial bryophyte specimens that are soft and delicate in tissue paper or newspaper to keep them intact.
4. Record the substrate for each specimen.



If possible, it is always better to press in the field than to collect into plastic bags—there is less chance of damage to specimens, mixed collections, and separated collections.



Bryophyte or lichen specimens filed in envelopes in drawers.



Labels on bryophyte envelopes and lichen boxes.

Recording information

The information recorded on the label is as important as the quality of the specimen. Apart from the collector's name and number and the locality, most of the label information concerns those aspects of the plant and its habitat that will not be visible on the dried specimen. The details on the label must be meaningful and unambiguous to anyone reading the label. All notes about the plants should be made in the field when the specimen is actually collected (or as soon as possible afterwards) and not at a later date. Experienced collectors will vouch how easily information can be forgotten or muddled if not written down immediately!

Enter each record in a field notebook, collector's register, or directly onto specially printed field labels (see Appendix 2). You can use any book as a collector's register and make notes about the locality and specimens collected before writing labels. Pre-printed field labels are useful—each label has most of the basic possibilities already printed on it, making it quick and easy to select the information applicable to the specimen in hand.

Basic label information

- Collector's name and number are unique to each specimen collected. All duplicates must be given the same collector's number as the original specimen. The collector's number is written on tags that can be attached to the specimen and its duplicates. The number is also written on the outside of the flimsies in which the specimen and its duplicates are pressed.
- Date when specimen was collected. The collection date gives valuable information on flowering and fruiting times of a taxon and can be used when planning trips to recollect a specimen, to continue research on the population, or to collect the taxon in other areas.
- Locality refers to the exact position of a specimen. Locality is measured by the latitude and longitude in degrees, minutes and seconds and, in the FSA (*Flora of southern Africa*) region, the quarter-degree grid square reference. When recording the locality, include the closest reference point (such as nearest town or well-known landmark) and the precise locality. This information is obtained from maps (1:250,000 or smaller) together with a GPS (Global Positioning System) instrument. Accurate localities give important information on distribution. They also enable collectors to return and collect in exactly the same place or from the same plant, for example, in the case of a tree.

Descriptive Notes

Record the following information for each specimen:

- Details likely to be lost in the drying process, for example, flower and fruit colour and markings, smell, milky latex, and stickiness.
- Information on characteristics not observable from the specimen, for example, time of opening or closing of flowers, taste, parasitic host plant, and light conditions.
- Aspect, altitude, vegetation type (grassland, forest, and so on), geology.
- Life form, size of plant, height, diameter of stem (trees).
- Habitat and factors like soil type and moisture regime (swamp, sand, or rocks, open places, shade, and so on).
- For bryophytes, fungi, and lichens, record the substrate for each specimen.
- Abundance—whether frequent or rare.
- Uses and local common names.
- Whether serving as a voucher (for example, for a painting, drawing, photograph, or seed bank material).
- Pollinator. ▲



For more information on plant collecting,
see the book *Preparing herbarium specimens*
(Fish 1999).

CHAPTER 3

pressing and drying



*People forget how fast you did a job —
but they remember how well you did it.*

— Howard Newton

After you have collected plant material, pressing is the next step in the creation of a specimen. Pressing flattens and dries the plants and makes it possible to mount and preserve them.

Main aims

When pressing specimens, your aims should be to

- Flatten the specimens as much as possible, as bulky specimens take up a large amount of space.
- Prevent wilting.
- Position specimens in such a way that the different parts of the plant are clearly visible.
- Preserve delicate organs without crushing them.

The plant press

Two things happen when you press plant specimens: the plant material gradually loses its moisture, while the pressure exerted on it by the press flattens the material.

Components of a plant press

A plant press consists of the following parts:

- Two strong, rigid, wooden or metal lattice frames slightly larger than the standard herbarium mounting board.
- Two expandable straps that are strong and easy to open, close, and tighten. (We suggest webbing with round or D-rings.) As the plant material flattens and loses moisture, the straps must be tightened regularly to ensure that the plants are pressed flat.
- Drying paper with good absorbing properties. The dimensions should be 280×450 mm, slightly larger than the standard mounting board. You can use newspaper cut to size as a substitute. Drying paper must be changed regularly during the first few days of pressing. This is even more important if the specimen has a high moisture content or the atmosphere is very humid.
- Flimsies should be of thin, strong, slightly absorbent paper. (The plant specimen is placed in the flimsy before pressing and kept in it until mounting). We recommend unprinted newspaper, but you can also use printed newspaper. Fold the paper from both sides with the opening in the centre to prevent material from slipping out. When folded, the flimsy should be the size of a standard herbarium mounting board (270×420 mm). The collector's name and number must appear on the outside in the lower right-hand corner. (Some herbaria prefer this to be in the upper right-hand corner.)
- Corrugated cardboard sheets are used as ventilators or spacers and must be the same size as the drying paper (280×450 mm), or slightly larger. To allow airflow to speed up the

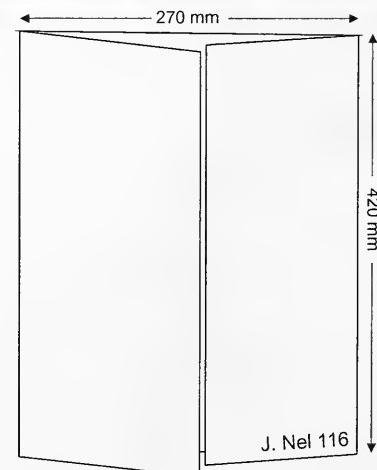
drying process, the corrugations in the ventilators must run parallel to the short sides. The ventilators also prevent bulky specimens from damaging ones that are more delicate.



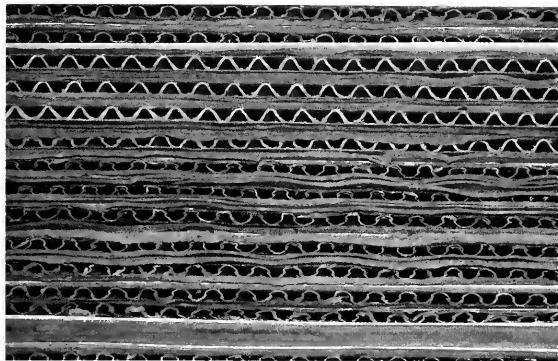
A packed plant press, with straps tightened.



A close-up of the straps and D-rings.



Flimsies correctly folded to show collector's name and number.



Cardboard ventilators are most effective when the corrugations run parallel to the short sides.

How to pack a plant press step by step

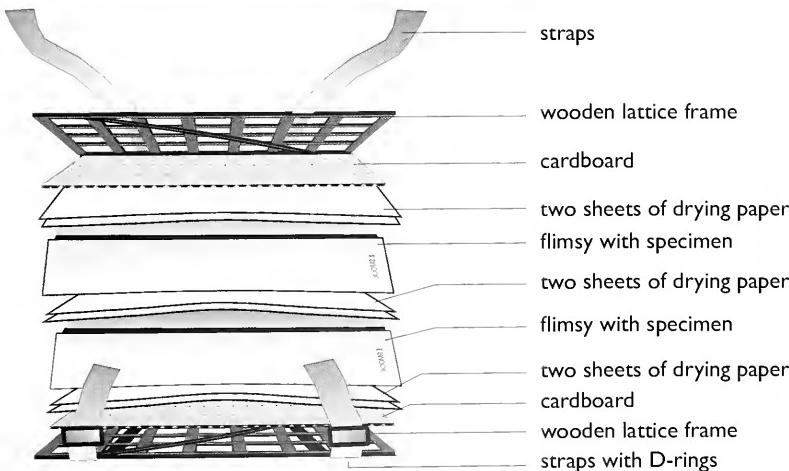
A plant press is packed in the following sequence:

1. Wooden lattice frame.
2. Cardboard.
3. Two sheets of drying paper.
4. Flimsy with specimen.
5. Two drying papers, followed by another flimsy with a specimen and so forth.
6. Use a cardboard ventilator after every five to eight specimens.
7. Finish with a cardboard ventilator and the second wooden lattice frame and then pull the straps tight.

Standard pressing methods

Correct pressing of specimens is very important: once a specimen has been pressed and dried, its overall shape cannot be altered without some damage.

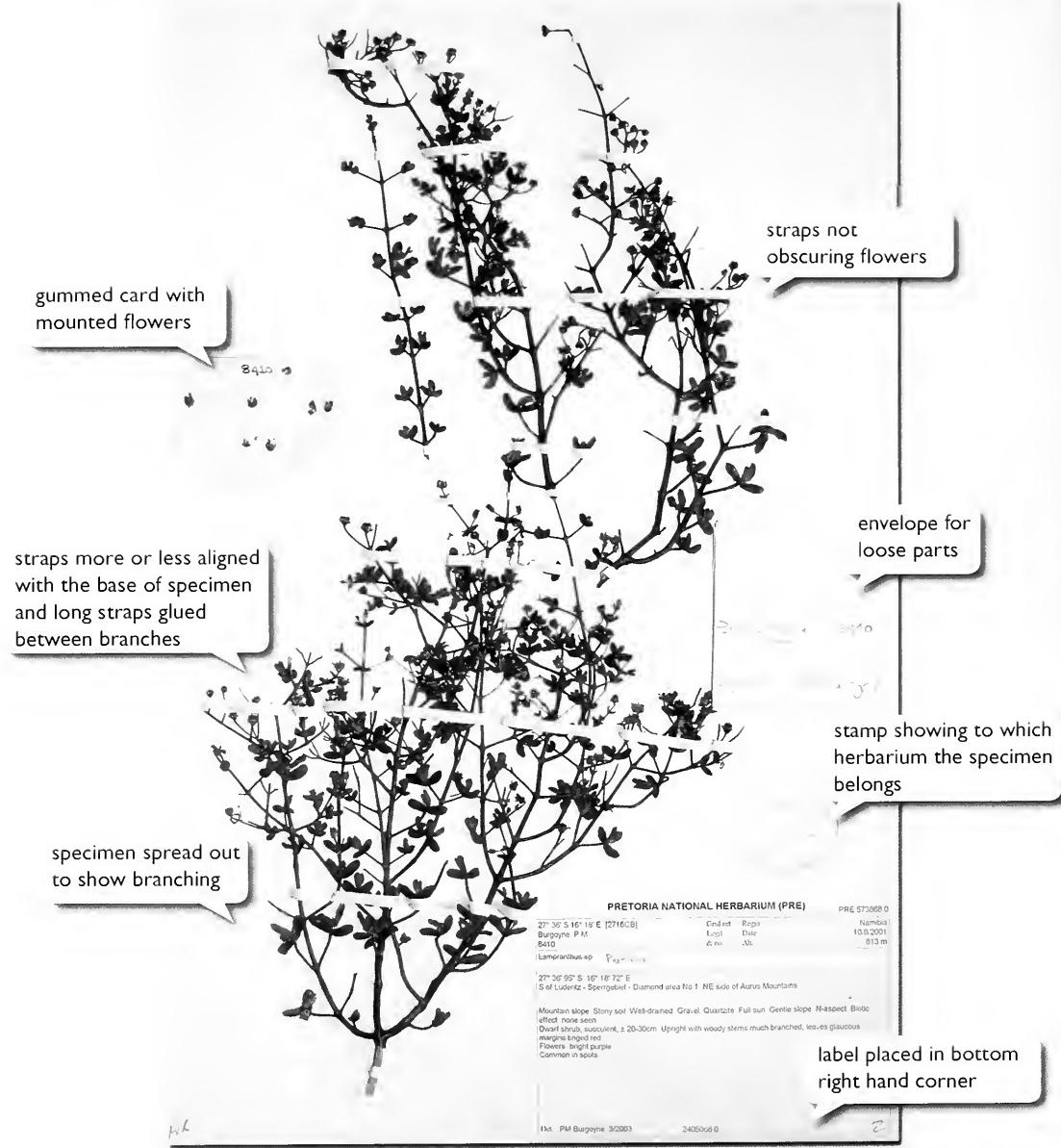
- The shorter the time between collecting and pressing, the better.
- Always keep mounting in mind. Remember the size of a standard mounting board (270 × 420 mm), the position of the label, and the orientation of the specimen.
- Remove mud and soil from roots and other basal parts.
- Spread the specimen out to show all the parts.
- Open some flowers and turn others over to show both inside and outside surfaces. A side view is also useful.
- Spread ferns out to show the shape and size of the individual pinnae—these can be different on the same frond, especially the basal pinnae.
- Leaves, especially those of ferns, should show both surfaces.
- Arrange specimens too large for the herbarium mounting board by bending or breaking them while still fresh, preferably without entirely severing the parts, to fit the board. If cut into different segments, they might become separated and cause confusion.
- Collect representative pieces of plant parts too large for standard mounting boards, for example, cycad leaves and fern fronds. The base, middle, and apex are usually adequate for most taxa.
- If the pieces are too large to fit into a single flimsy, label each piece sequentially (Sheet I, Sheet II, Sheet III, and so on) and press in a separate flimsy with the collector's name and the



The sequence in which a plant press is packed.



characteristics of a good specimen



P After 12 to 24 hours in the press, you can rearrange unmanageable specimens in their flimsies—they will still be partially damp and easier to handle.

same number. (These are not duplicates, but sheets of the same specimen.)

- To reduce bulk, split or cut large specimens with thick stems, roots, corms, or bulbs. Even flowers, seeds, and fruits can be split or cut. This saves space and prevents damage to other specimens in the herbarium cupboard.
- Pad specimens that have parts which are much thicker than others: place absorbent paper over the thin parts, bypassing the thicker parts, to even out the pressure within the press and to prevent wilting of the thinner parts. A quicker method is to use sheets of foam rubber, cut to the same size as the drying paper.
- Remove excess leaves or flowers that obscure each other or other organs; leave part of the petiole or flower stalk to show that something has been removed.
- With delicate or short-lived flowers, it is best to take extra ones and place them in wax or tissue paper and press them separately. You can also use small, gummed cards, especially if the pressed flowers have to be dissected. See “Fragile flowers”.
- Place small seeds in an envelope with the collector’s name and number written on it; this is pressed with the specimen.
- Place the thick parts of specimens alternately at different positions in the flimsies to keep the press even and level and to ensure that all parts, especially thinner ones, are being pressed properly.

Special pressing methods

Not all plants can be pressed using the standard methods. Some plants, such as succulents, bulbs, spiny plants, and delicate flowers, need special handling.

Succulent and fleshy plants

Succulent and fleshy plants usually have a very high water content, which makes drying difficult. Some also tend to remain alive—even in the press! There are a number of techniques to overcome this problem:

- Plant material can be cut longitudinally or transversely, and the fleshy inner tissue can be cut or scraped out before pressing. This method works well for leaves of *Aloe* species.
- You can kill plants by submerging them in very hot water or in a liquid such as methylated spirits (denatured alcohol), petrol, or even household vinegar. Pierce the material with a

needle to allow penetration of the liquid.

- Place plant material—unpressed—in a freezer for two days, then microwave.
- Prepare flowers of the Stapelieae (Asclepiadoideae) and Mesembryanthemaceae using the gummed card method to improve the quality of the specimens. See “Fragile flowers”.



Graminoid that has been bent to fit the sheet.

Graminoids

Graminoids include plants from the Poaceae, Cyperaceae, Restionaceae, and Xyridaceae. They are often tall and difficult to fit onto a herbarium sheet. Bend the stems by bruising them with a fingernail. Do not cut unless absolutely necessary.

Fleshy underground organs

Bulbs, corms, and other fleshy underground organs are too bulky to press whole. Slice these parts longitudinally into thinner segments. In addition, these organs tend to remain alive, sometimes even after they have been cut. To kill the tissues before



Bulbs sliced for pressing.

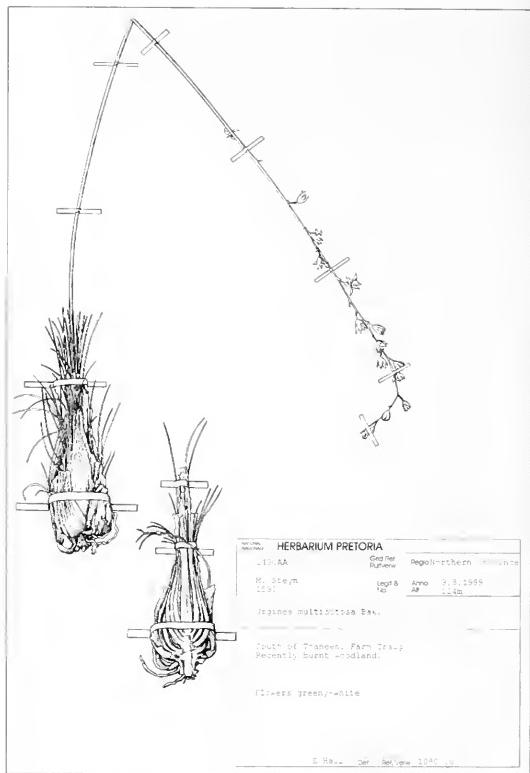
pressing, use hot water, methylated spirits, petrol, or vinegar as described under "Succulent and fleshy plants" above.

Spiny plants

Place the spiny plant in its flimsy in the press with a number of cardboard ventilators below and above the specimen (enough to prevent thorns from piercing through). Press down firmly. It should be possible to bend many of the thorns so that the specimen can be pressed in the usual way. Remove long or rigid spines and thorns that protrude along the upper or lower surface of a specimen if you cannot bend them easily.

Fragile flowers

Usually, flowers from dried specimens are rehydrated for microscopic examination of floral parts. The dried flowers of families like Iridaceae, however, disintegrate easily and are therefore too fragile to rehydrate. In other families, such as Acanthaceae, the



Well pressed bulbous specimen.

flowers often fall off the dried specimen. In such cases, you can dissect and preserve fresh flowers in another way to allow detailed studies later. This is also important for families, such as Mesembryanthemaceae, where taxonomically important characters are found inside the flowers.

One such method, devised by Dr Louisa Bolus, uses gummed cards. Cards are covered with gum Arabic, allowed to dry, and placed in an airtight container until needed. After dissecting the flowers, you place the fresh material on the lightly moistened gummed card, cover it with cellophane, and place it in a mini-press until dry. The card can then be mounted with the specimen. Burgoine & Smith (1998) describe an alternative method using archival, acid-free gummed paper; the specimens are covered with wax paper and then dried in a plant dryer. This method is less messy than the gum Arabic method and gives very good results.

preparing a succulent flower for pressing



1. Remove a flower.



2. Cut longitudinally through centre.



3. Separate halves.



4. Place onto moistened gummed paper, cut surface uppermost.



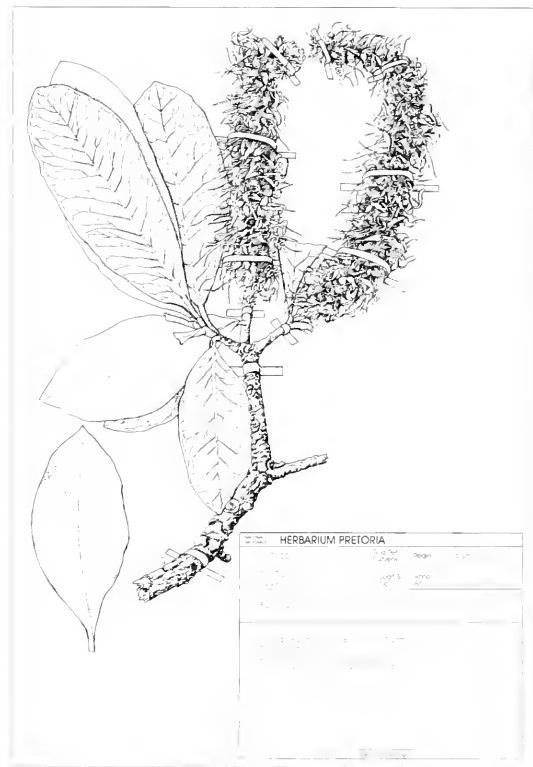
5. Cover with wax paper.



6. Write collectors number and name onto gummed paper.



7. Press mounted flower with the rest of the specimen.



Bulky specimen with some leaves removed.



Preserved specimens in bottles.



Write the type of preservative clearly on the airtight glass or plastic jar used for preservation.

Fixatives and preservatives

Parts of some plants, for example, *Stapelia* flowers, are often best preserved by placing them in a preserving liquid or fixative. This method of preservation retains the shape of parts and organs important for identification.

WARNING

Formaldehyde is carcinogenic

Fixatives and preservatives

Constituents and uses of the most commonly used herbarium fixatives and preservatives

Alcohol or IMS	Industrial Methylated Spirits (IMS), ethanol, or ethyl alcohol	Use only if no good fixative is available; can be used for storage but has a limited shelf life.
FAA	1:1:18 mixture of 40% formaldehyde, glacial acetic acid and 70% ethanol	Fixative for histological use; indefinite shelf life. Remember: formaldehyde is carcinogenic.
Kew mixture	10:1:1:8 mixture of IMS, formalin, glycerol and water	Very good fixative for histological use.
Carnoy's fluid	3:1 mixture of 96% absolute alcohol and glacial acetic acid	Fixative for cytology; replace with 70% ethanol after fixing for 24–48 hours.
Copenhagen mixture	10:1:8 mixture of IMS, glycerol and water	Very good for storage, but not a good fixative.

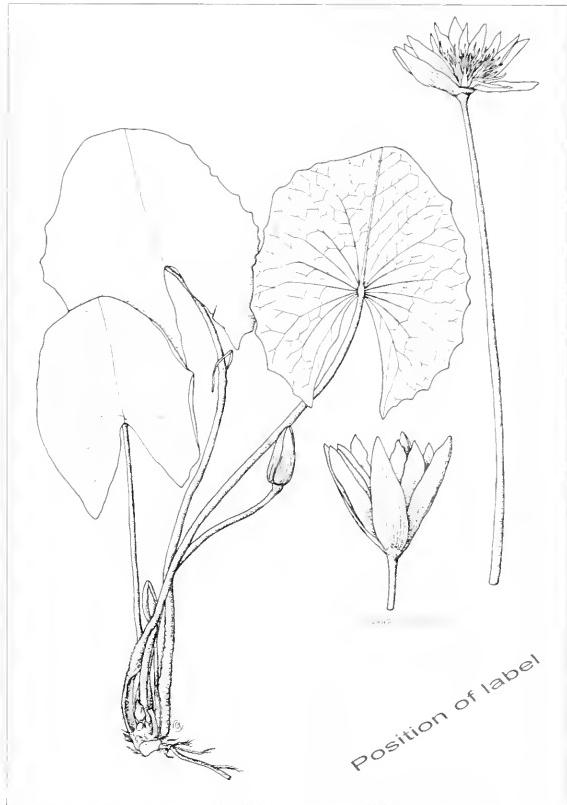
Working with poisonous and hazardous chemicals

When handling hazardous chemicals, or specimens treated with poisons, you should always take appropriate protective measures and be familiar with emergency procedures.

- Know how to use respirators correctly.
- Work in a well ventilated area.
- Make use of personal protective equipment, such as chemical safety goggles, impervious gloves, overalls, and aprons.
- Wash hands after working with poisonous or hazardous chemicals.
- Do not eat, drink, or smoke in work areas.
- Ensure that there is an easily accessible shower and eye wash fountain available in the immediate work area.



Specimens that are bulky and too large to fit onto one sheet should be cut into pieces that will fit onto the sheet. Each is then mounted on its own sheet, and the separate sheets are labelled "Sheet I, Sheet II" and so forth (as described on p. 42). All sheets should have identical labels. Particularly bulky specimens like these cycad leaves should be attached securely by sewing them to the sheet.



A well laid out *Nymphaea* specimen showing the different features of the plant.

Fungi

Fleshy macrofungi are not pressed, but dried as rapidly as possible after collection. Very large fruiting bodies can be cut lengthwise into two or more slices.

Rusts and other plant pathogenic fungi are collected on the host plant and pressed and dried in the same way as vascular plants. See "Standard pressing methods".

Aquatic plants

The procedure for pressing aquatics is similar to that for terrestrial plants, except for a few specialised techniques.

TIP If plants appear to be drying too slowly, put the press in a freezer for a day or two and then return it to the dryer. Freezing breaks the cell walls and makes it easier for the moisture in the plant to be drawn out by the drying process.

- Because aquatic plants are wet, they need several sheets of drying paper and a cardboard ventilator between all specimens; these must be changed frequently.
- Place small, free-floating plants, such as *Lemna*, individually on small pieces of archival-quality acid-free paper. Place all the squares in a flimsy before pressing them. When the plants are dry, you can mount the individual squares.
- Make notes on the growth form, the form of the rootstock, and the number and arrangement of emerging leaves, as these are essential characters used in the identification of aquatic plants.
- Flowers—those of *Nymphaea* species, for example—should be cut in half and some of the petals and stamens folded forward to show the number and arrangement of the stamens.
- Venation of the upper and lower surface of the leaf and the way the veins join the petiole are important diagnostic characters in many groups; in such specimens, cut the leaves (especially large leaves) in half, slightly off-centre, and mount to show these characters.
- The mucilaginous layer of leaves of some aquatics acts as an adhesive, sticking the specimen to the flimsy. Petals are often thin and delicate and tend to stick to the flimsy. To prevent this from happening, spread the plant out on a sheet of acid-free paper in the position in which it will be mounted on the herbarium sheet. Cover it with a protective layer of ordinary wax paper, the waxed side against the plant. Prick several holes in the paper so that the drying paper can absorb the moisture on the plant. You can also use thin perforated plastic, although this is not recommended in tropical areas. The preferred method in these areas is to press the plant between two pieces of thin cotton cloth (cheesecloth) or dressmaker's non-fusible interfacing. When the drying papers are changed, gently loosen the plants from the protective layer.
- You can attach flowers to a piece of gummed paper and cover them with a piece of wax paper, before placing them in the press. See "Fragile flowers".

Submerged plants

When submerged plants are removed from the water, the leaves adhere to each other. Prepare such specimens for pressing in one of the following ways:

- **Floating** Immerse a clean sheet of acid-free white paper in water in a flat, shallow dish; spread the plant out on the paper and slowly lift the sheet and plant out of the water. A thin sheet of polystyrene under the paper helps to support both plant and paper during the lifting process. This method works well for plants such as *Potamogeton pectinatus*.

preparation of submerged aquatic plants



1. Place a sheet of white paper on a rigid board into a shallow dish, then add the plants.



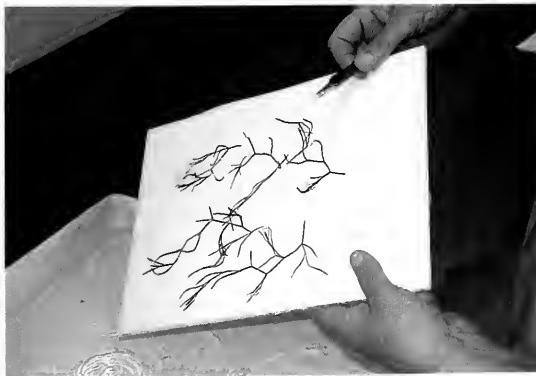
2. Gently move the floating plants onto the sheet.



3. Lay out to show all characters.



4. Start lifting the board while holding the board and specimen in position.



5. Tilt the board while lifting it out of the water to remove excess water.



6. A mounted specimen.

- Air-drying Place delicate plants in a cotton bag and swing the bag around a few times, shake it gently, and then spread the plant out on a sheet of acid-free white paper; more robust plants can be shaken dry without a bag. This method works well for plants such as *Potamogeton pusillus* and *Potamogeton crispus*.

In both methods, the plants will adhere to the paper, which you can mount straight onto the herbarium mounting board after pressing and drying. If the plant does not adhere to the paper, secure it with a few gummed paper straps. (See "Strapping".)

Drying specimens

We are lucky to have the hot African sun to help us with specimen drying—it is easy, as well as free!

- The drying process should take place in a warm, dry location. The ideal drying temperature is 45°C. Very high temperatures cause plants to become brittle.
- Plants must dry out fast, otherwise the flowers and leaves tend to drop off the specimen.
- Change the layers of drying paper in the press regularly; they become damp from the moisture absorbed from the plants. Repeat this process daily, especially during the first few days. After the first week, longer intervals can be allowed between changes, unless the atmospheric humidity is very high. Cardboard ventilators must be changed as well, especially during the first few days.
- It is not necessary to remove specimens from their flimsies when changing the drying paper.
- Loosen the specimens from the flimsies before they are completely dry. This is important, as many plant parts tend to adhere to the flimsies during the drying process and are then difficult to remove later without some damage to the delicate parts.
- The tissues of succulents and bulbous plants often have to be killed before the drying process will proceed. For more information on killing tissues, see "Succulent and fleshy plants".
- Check regularly for live insects eating the flowers and leaves while the specimens are in the press.
- A specimen is dry when a white mark is left behind when you run your fingernail along the surface of a leaf.
- Air-dry bryophyte specimens as soon as possible after collecting to avoid fungal and abnormal shoot growth, and to discourage attack by insects. Open the paper bags in a dry place with good ventilation. Artificial drying procedures should be avoided.
- Fleshy fungi should be dried rapidly at approximately 40°C; take care not to overheat and cook the specimens! Too low a

temperature will result in insect larvae hatching and eating the specimen. Small fungi can be air-dried. ▲



For detailed information on pressing and drying, see the book *Preparing herbarium specimens* (Fish 1999).



Specimen with extra padding around bulky inflorescence.



It is always best to press in the field.

mounting specimens



Only those who have the patience to do simple things perfectly, will acquire the skill to do difficult things easily.

—Friedrich von Schiller

It might seem easier to handle unmounted specimens, but normal handling easily damages them—dried plant material tends to be very brittle. The practice of mounting dried specimens reduces such damage. This is important because many specimens are irreplaceable and damage or loss of fragments would render them scientifically worthless. If you take care of them, well-mounted specimens can last indefinitely.

Main aims

When mounting plant specimens, your aims should be to

- Make the specimen easier to handle and more accessible for study or reference.
- Display the specimen to allow maximum observation of all characters.
- Display all labels clearly.
- Prevent damage and to preserve the specimen by attaching it firmly to strong acid-free paper or board.
- Use attachment materials that can be removed and replaced easily. This allows clearer observation of the specimen and makes it easier to remove small parts for more detailed study.

Material and equipment

- White mounting boards of good quality, preferably acid-free, of a standard size (270 × 420 mm) and weight (300 gsm and 400 gsm).
- Glue and applicator (for example, the nozzle of the glue bottle, a paintbrush, or a scalpel).

P **White glue, wood glue, and poly(vinyl acetate) (PVAC) adhesives are strong. They are also acidic, and may damage specimens over time.**

T **Methylcellulose is not as strong as white glue types, but does not damage specimens and is completely removable.**

- Firm paper (230 gsm) for bryophyte and lichen envelopes.
- Envelopes for small (or extra) flowers, fruits, leaves, and seeds.
- White gummed paper or self-adhesive paper cut into strips, used to attach specimens to mounting boards.
- Paper towels for mopping up excess glue.
- Thick sheets of corrugated cardboard, slightly larger than mounting boards (280 × 420 mm), for supporting specimens while glue is drying.
- Wax paper (slightly larger than the mounting board) stapled to drying paper; this is placed on top of freshly glued specimens to prevent the glue from sticking to the sheet above

while it is drying.

- Labels for indicating that a specimen consists of more than one mounting board, for example, "Sheet I" to "Sheet IV".
- Scissors, knife, forceps, and scalpel.
- Small, flat, steel weights for holding down parts of the plant while mounting.
- Small paintbrush for removing dirt from the specimen.
- Thick needle and thread such as raffia, for attaching extra-bulky parts.
- Sandbags, weighing about 5 kg (made of dense material like canvas, to avoid sand from filtering through), for putting pressure on a stack of specimens while the glue is drying.
- Firm, rigid surface (such as wood or plastic) of the same size as a mounting board, to place underneath the sandbag to ensure that the weight is evenly spread.
- Sponge and saucer with water to wet gummed paper straps.
- Pen with waterproof ink, pencil, and a good quality eraser.
- Herbarium name stamp and pad, self-inking stamp, or label with herbarium name. The specimen is stamped or labelled on the right, above the main data label, to indicate that it belongs to a specific herbarium.

P **Once a plant is dry, it becomes brittle and very difficult to rearrange for mounting purposes without damage. You can, however, try soaking dry material in boiling water and then re-press it once it has softened.**

Mounting procedures

Start by deciding whether you want to mount all the material, or only the best specimen(s) from the duplicates that show all the characters and variations of the plant in the collection. Next, select mounting boards of the appropriate weight: lighter for delicate specimens, and heavier for specimens that are more robust. Then, mount the specimen in the following sequence (described in more detail on the following pages):

- Arrange the specimen.
- Store small loose parts in paper envelopes.
- When attaching the specimen to the board, ensure that there is enough space for the main label to be glued in the bottom right-hand corner.
- Glue the label to the board.

Arranging the specimen

Clean off sand and dirt adhering to the specimen, using a fine paintbrush, or by gently blowing on the specimen. Arrange it on the mounting sheet; do not merely show the most pleasing or artistic arrangement, but keep the scientific purpose in mind,

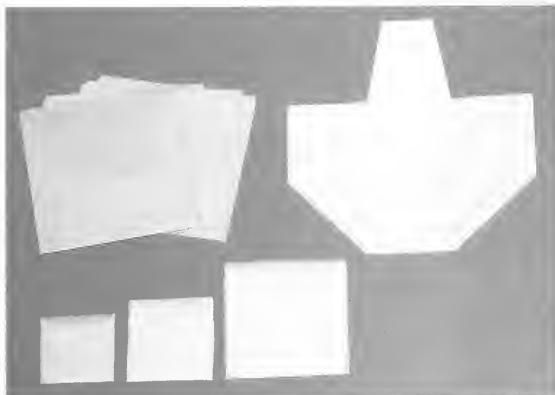
presenting the specimen to display all its characters.

- Display both sides of leaves and flowers, and for ferns, both sterile and fertile surfaces.
- Expose hidden flowers or fruits by removing excess leaves and placing them in a paper envelope, together with any other small, loose parts.
- Do not clump parts together for easier and quicker mounting. If necessary, larger parts can be mounted separately on the sheet.
- If parts of the specimen have to lie on top of each other, try to mount the more delicate parts below the bulkier ones.
- Specimens should not protrude over the edges of the mounting board.
- Specimens should not be mounted underneath or over the main label.
- Try to keep all specimens on one sheet aligned in the same direction. If possible, always place the largest or heaviest specimen at the bottom to prevent the sheet from bending when it is handled.
- Larger specimens are best arranged diagonally.
- Trim plants only if there is no other way to fit them on a standard mounting board.
- Trim lumpy specimens with projecting spines or branches that could damage adjacent sheets in the herbarium cupboard.

Envelopes

Small loose parts (including important parts trimmed from the plant), tiny plants too small to mount, and very delicate specimens or parts, should be placed in an envelope.

- Envelopes containing tiny plants should be placed centrally



Different types of envelopes used for holding loose plant parts, or very small plants.

on the sheet with one or two plants mounted outside the envelope, if possible, as examples.

- Write the collector's name and number on the envelope in case it becomes detached.
- Envelopes containing loose parts are usually glued to the top left of the mounting board, but the position depends on the space available.
- There are a number of different designs and sizes of envelopes. When folded and glued to the board, the envelope should stay closed to keep small seeds or parts from falling out. It should fold open flat to allow observation without damaging the plant.
- Dissected material, seeds, or other parts that become detached from the specimen, should also be placed in an envelope.

Glueing

Keep the following guidelines in mind when glueing specimens to the mounting board:

- Glueing is irreversible and often covers important characters. Therefore, use as little as possible. Do not apply much glue to the base of plants as it may cover important features like scales or hairs. This is especially important in the case of ferns. Excess glue also prevents easy removal of parts for study purposes.
- Wood glue is long-lasting and dries clear. Delicate parts, or those often needed for dissection, should preferably not be glued. If it is absolutely necessary to use glue, use a water-soluble adhesive, such as methylcellulose.
- Apply the glue to the back of the specimen. Take special care that it remains invisible from above.
- Wipe off any excess glue with a paper towel or toilet paper, and then place the specimen on the mounting board.
- Work fast and apply the glue in one go to prevent delicate leaves from absorbing water from the glue and curling up.
- Cover each specimen with wax paper to prevent any excess glue from sticking to other specimens or sheets. Stack the glued specimens between corrugated boards, with a sandbag placed on top as a weight to ensure that the specimens are pressed flat while the glue dries. Support the sandbag with a wooden board or similar object. Leave the specimens like this until the glue has dried. Keep unevenly bulky specimens separate from the main stack.
- Handle specimens on which glue is drying with care, since movement may cause a specimen to shift or break.
- Often a small tag bearing the collector's number is attached to the specimen by a thread. This tag must be glued onto the sheet and preserved with the specimen. If there is writing on

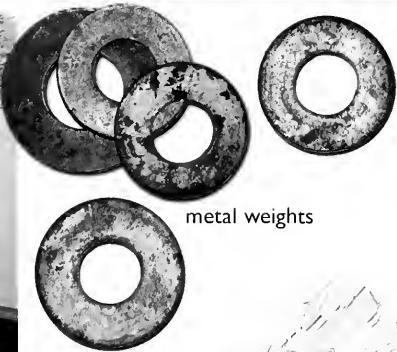
materials and equipment for mounting



A staff member with all the materials and tools used during mounting.
Note the metal weights on the specimen in the foreground.



Fixing a gummed paper strap.



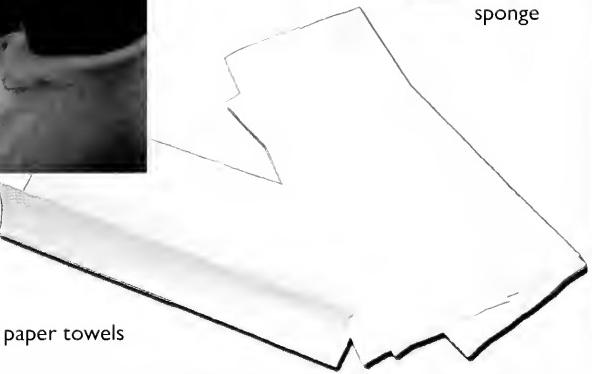
metal weights



gummed paper



sponge



paper towels

materials and equipment for mounting

raffia and needle



typical label



instruments

specimens interleaved with wax paper while glue is drying

paint brushes



A sandbag placed on top of a stack of mounted specimens ensures that the specimens remain flat while the glue is drying.

rubber stamps and ink pad



both sides of the tag, leave it loose, tucked under a part of the specimen.

Strapping

When the glue has dried, fasten all loose parts with gummed paper straps. Strapping is reversible, allowing for easy removal of parts for detailed studies.

- Straps of suitable width should be used (2 mm, 3 mm, or 6 mm). Use narrow straps on finer parts of the specimen and wider straps where extra strength is needed, for example, over thick stems.
- Place straps across the specimen at regular intervals and stick both ends to the sheet. Apply enough straps to hold the specimen firmly in place, should the glued parts come unstuck, but do not overstrap so that the specimen is obscured.
- Straps should extend 10–15 mm beyond the part of the specimen that is to be strapped down.
- Straps should be tucked in under the plant parts to hold the specimen firmly in place. Use forceps to tuck straps firmly around and under stems.
- Avoid strapping over important details such as flowers, small inflorescences, or the base of a plant. Exceptions to the rule are large flowers or flowering heads and very long, delicate inflorescences that obviously need extra support to prevent damage. In such cases, place the straps near the base and along convenient points.
- Individual straps should not cover large amounts or different thicknesses of material, as it is difficult to stick the strap properly. Consequently, the plant will not be held firmly.
- Wherever possible, align the straps in one direction, preferably parallel to the bottom of the mounting board.
- Do not over-wet straps, as they will fail to stick to the sheet.
- Gently feel to make sure all the parts have been fastened down.

Stitching

Sewing with needle and thread is used to attach very bulky parts of a specimen to the mounting board. Thread that is strong, but not very thick, or natural raffia is suitable. Stitches are knotted off on the back of the mounting board and the knots are covered with gummed paper. This prevents the thread from catching on underlying specimens when filed in the herbarium.

Mounting labels

The following pointers will guide you when mounting labels on the herbarium sheet:

- Labels can be glued to the herbarium sheet either before or

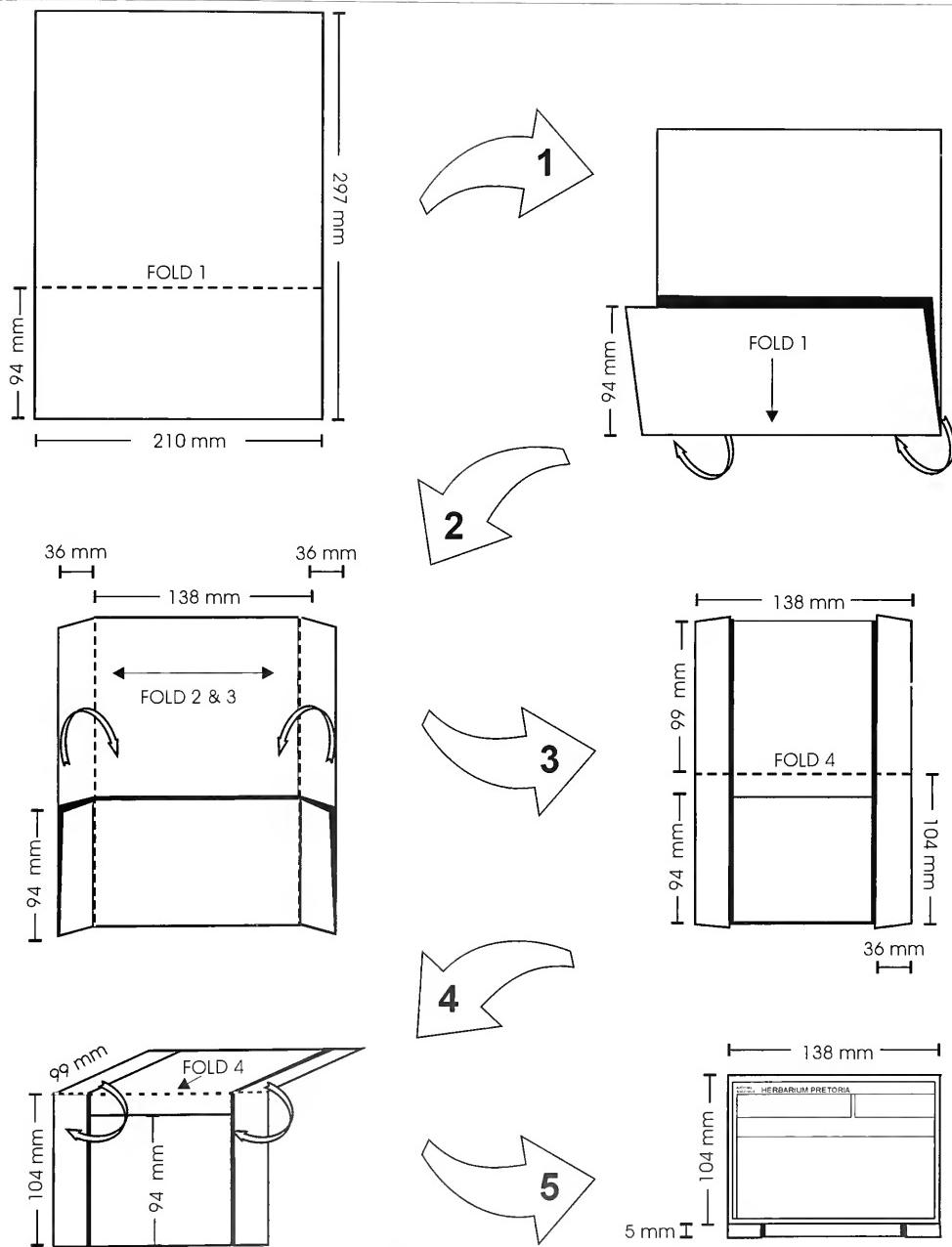
after mounting the specimen.

- New labels should be typed or copied if the main labels are of a poor quality, but the originals must be retained with the specimen. You can mount the originals in the top left-hand



A well mounted specimen sewn to the board.

P Inflorescences of *Typha* species (bulrushes) tend to explode on the herbarium sheet after some time. To prevent this, wrap the inflorescence in polyester film (for example, from a cooking or oven bag) when mounting, tying both top and bottom to prevent the minute flowers from spreading if the inflorescence does explode. Ordinary plastic bags and cellophane are not archival materials and should not be used.



Pattern for folding envelope from A4 sheet.

corner, either directly on the sheet or in an envelope. Glue the main label in the bottom right-hand corner.

- Do not place the label across any part of the specimen or underneath it.
- Daub glue sparingly round the edges of the entire label, place it on the mounting board and smooth it out with a paper towel or piece of flat, clean cardboard. Never glue only one edge of a label. Wipe off excess glue.
- Leave a space above the main label for the herbarium stamp and any other labels.

Preparing bryophytes and lichens for storage

Bryophytes and lichens are not mounted and stored like most other plants. The following guidelines will help you to handle these delicate specimens correctly:

- Remove excess soil and leaves from bryophytes using a fine sieve: soil sliding around in envelopes can damage specimens. *Do not wash.*
- Envelopes should be made from stiff paper to protect the specimen from being squashed. Envelopes can be made to fit the inside of any available box or cabinet; a useful standard envelope (104 x 138 mm) can be folded from an A4 sheet of firm paper. (Pattern on page 37.)
- Paint wood glue onto the underside of lichens lifted from soil; this prevents fragmentation of the specimen.
- Place very small and delicate specimens in smaller envelopes or wrapped in tissue paper before placing them inside the herbarium envelope.
- Mount lichens that are attached to rock chips on a piece of card, and put the card in a slightly larger envelope.
- Write collecting data on the envelope, or glue a label to the outer flap.
- If the specimen is attached to bark or branchlets, put it straight into the envelope, unmounted.
- File envelopes vertically in a metal card-filing cupboard or in drawers. ▲

TIP

Once dry, bryophytes and lichens are rarely attacked by insects, making fumigation or other anti-pest measures unnecessary.

packing and storing bryophytes and lichens



The herbarium worker uses envelopes folded from A4 sheets. (Pattern on page 37.)



The specimen is placed on the opened envelope, which is then folded again to secure the specimen.



Placing a lichen specimen on a rock chip in a small box.

CHAPTER 5

physical curation



He had read...that the process of arranging one's thoughts in good order was often helped by an equally careful ordering of external objects.

—A. Wilson

Physical curation involves the preparation of herbarium specimens and their handling, storage, and conservation within the herbarium. Methods for specimen storage are based on certain conventions, but have been customised around the world by many different herbaria. Consequently, numerous methods are practised. The methods outlined in this chapter highlight what we see as the most practical and efficient systems for curating a specimen collection.

Storing specimens

Groups of specimens are stored in species covers, which are in turn stored in genus covers.

Species covers

For species covers, firm acid-free paper is used. When folded in half, the cover should be slightly larger than a mounting sheet (550 mm × 420 mm unfolded).

The taxon number (obtained from a revision or Flora), species name, and author should be written in pencil on the outside of the cover, in the bottom right-hand corner. It can be useful to include distribution information on the species cover.

Information pertaining to the species, such as copies of references, notes on similar species, distinguishing characters and uses, common names, photographs, maps, and magazine articles, is best

kept in its own species cover, marked "Notes" or "Literature" at the beginning of each species. A separate file at the beginning of a family or genus can be used to store information about that family or genus.

Genus covers

Strong folders are used for holding a few species covers containing specimens. It is best to use thin card or



Genus cover showing genus name, numbers and geographical area at the bottom.



Specimens and folders.

thick paper, acid-free, slightly larger than a mounting sheet when folded (570 mm × 430 mm unfolded) with a central spine (two folds 1 cm apart). The genus name and number should be written in permanent ink; species names are written in pencil, because they are more subject to change. The genus and species names, numbers, and geographical area labels are usually placed at the bottom, which makes it easier to search through a pile in the cupboard without having to pull the pile out completely. Colour-coded hanging tags make it easier to distinguish different regions (or countries).

Type covers

Type covers indicate the presence of type specimens. Even if the specimen is a photograph or a fragment of a type, it should be placed in a type cover. Strong acid-free paper is folded in a special way to ensure better protection and to keep the specimen from falling out when the cover is handled. To make the cover conspicuous, a coloured band (by convention red) is printed or marked along the bottom edge.



Write the genus and species names at the bottom of the back outside cover for specimens stored on the top shelf of tall cupboards, so that they can be read from below.

guidelines for handling specimens

- When working with specimens, take all specimens from a shelf.
- Place a card with your name in the pigeonhole so that other workers know where specimens are.
- Keep cupboard doors closed to prevent insects and dust from entering.
- Never write on a specimen's main label; if writing on the mounting sheet, use pencil and keep it to the minimum.
- Specimens should always be kept horizontal and flat and must never be bent; hold both sides of the sheet when handling specimens; when carrying specimens, place them on a sheet of cardboard.
- Never shuffle specimens as the edges of sheets may cut underlying specimens.
- Look through specimens by stacking and unstacking each specimen individually with the plant facing up. Do not page through specimens like pages in a book, or stack specimens with the plant facing downwards.
- Never rest an object on a specimen.
- Specimens can be damaged by sunlight, dust, wind, and moisture, and should always be protected when not in use. If specimens are left out of a cupboard, they must be covered with a cardboard sheet.
- When storing specimens, do not pack them tightly onto one shelf; do not overfill genus and species covers.
- When replacing specimens in the cupboard, make sure the sheets are all aligned, as protruding edges may be damaged.



This page can be photocopied and handed out to visitors for instructions on how one expects
them to handle specimen collections.

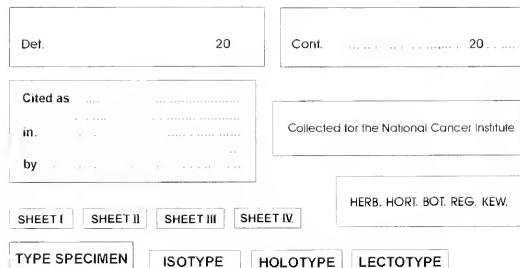
Write the details in archival ink on the bottom right of the cover, stating kind of type, name of taxon, reference for publication of the type, collector and collector's number, family number and genus number (where applicable). Locality—at least country)—can also be useful. For more information on types, see "Type specimens".

Labelling specimens

Labels are very important parts of herbarium specimens and should be thoroughly glued down to prevent tearing.

The following kinds of labels are used on specimens:

- **Main label:** The basic data label, specifying essential information, is placed at the bottom right hand side of the mounting board.
- **Original field label:** Usually placed at top left hand side of the mounting sheet. Any tags used by the collector are mounted with the specimen.
- **Nomenclature labels:** Placed as close to the main label as possible, in the nearest available space. If no space is available, it can be glued on one side only with the label over the plant (preferably not obscuring taxonomically important characters, such as flowers, or the base of the plant). These labels include the following:
 - **Det. (determinavit = determined) or Conf. (confirmavit = confirmed)** labels give the date and name of the plant and



Various types of labels.



person who did the identification or confirmed the name. Duplicates of such specimens, not seen by the person who identified the original, should be labelled with the words "ex num." (*ex numero* = from the number), meaning another specimen with this number was identified.

- **Cited or Quoted labels** record that the specimen has been cited in a publication. Such labels give the plant name, the reference, the author, and date of publication.
- Various small labels with other information are usually placed near the bottom of the sheet. Examples of such labels include the following:
 - Sheet I, II or III where more than one sheet represents a specimen (see page 27 for example)
 - Type specimen
 - Voucher specimen
 - Cross-references to the ancillary collections
 - Notes concerning removal of pollen or other material
 - Quarter-degree grid reference
 - Treatment for insects (type and date)
 - "Flora of Tropical East Africa", an example of a specimen that forms part of a collection of a particular area.
 - Origin of specimen, for example, "Ex herb. Harare" (*ex herbariom* = from the herbarium)
 - Herbarium name label (can be a part of main label or a stamp)

Producing labels

The following guidelines are useful when creating labels for specimens:

- Use unglazed and acid-free bond paper of good quality.
- Self-adhesive labels such as *Det.* slips or *Cited* as labels should be of archival quality. Ordinary self-adhesive labels fall off after a while, or can become transparent or discoloured. Alternatively, use acid-free paper labels, glued with permanent adhesive such as wood glue or methylcellulose.
- Avoid using correcting fluids on labels, as they are very acidic and can damage the paper over time.
- Labels should preferably be printed or typed. If hand-written, use permanent, waterproof, black ink.
- Photocopies of labels will suffice for duplicates.

Accession numbers

There are various uses of the term accession number. It most commonly refers to the number in a register (usually a book) kept to record all incoming specimens that are incorporated in the herbarium. It can also occasionally refer to the number given when computerising the collection. If there is no register and no collector's number (usually recorded as *s.n.*; *sans numero* = without a number), the specimen can be given a herbarium accession number.



Laser printer toner is permanent and is of archival quality. Bubble jet and Deskjet ink is NOT waterproof.

Filing specimens

Plant specimens are arranged either systematically or alphabetically; sometimes a combination of the two systems is used. For a comprehensive summary of classification systems, see Brummitt (1992).

Alphabetical arrangement

In an alphabetical arrangement, families, then genera within the families, and finally the species within these genera, are arranged alphabetically. Alphabetical arrangements are seldom used at the family level, sometimes at the genus level, and frequently at the species level. The advantage of an alphabetical system is that it is easy for the non-specialist to find taxa. The disadvantage is that related—and therefore similar—taxa are placed far apart, so that identification by matching becomes more difficult. (A Quick Guide can overcome this disadvantage; see "Quick Guides".) Errors can also creep in easily; for exam-

ple, a taxon can be filed under an old name as well as under another name, without it being noticed.

Systematic arrangement

Within a systematic arrangement, similar families and genera are placed close to one another, facilitating identification by matching. The two most commonly used systems by which families are arranged, are

- Dalla Torre & Harms. 1900–1907. *Genera Siphonogamarum*. This arrangement is usually referred to as the Englerian system, as *Genera Siphonogamarum* is a numerical arrangement of the system of Engler and Prantl's *Die Natürlichen Pflanzenfamilien*. This is the basis of the system used at PRE.
- Bentham & Hooker. 1862–1883. *Genera Plantarum*. This work is the basis of the system used at Kew.

When a systematic arrangement is used, it can be difficult for the non-specialist to find families and to incorporate new material into the collection, as this requires specialist knowledge and a good reference to the filing system. Another disadvantage is that a major change in the systematic arrangement, resulting from recently published research, can make it necessary to change the physical arrangement of much of the collection.

Further subdivisions

Within both the systematic and alphabetical systems, the specimen arrangement can be subdivided further into major and then minor geographic regions or floristic regions (for example, *Flora zambesiaca* region, *Flora of southern Africa* region). An example of geographical arrangement is that used at PRE. The major regions used for each genus are FSA (Flora of southern Africa), Tropical Africa (rest of Africa), Indian Ocean Islands, Sub Antarctic Islands, and Extra Africa (rest of the world). Within these, most are subdivided further into countries (for example, Angola, Zambia), or Floras (for example, *Flora zambesiaca*, *Flora of Tropical East Africa*).

Within species, geographical subdivision into province, grid reference, or region is often used. Geographical arrangement facilitates identifying by matching or searching for a specific specimen. In addition, incorrectly identified specimens would stand out if their distribution did not match.

Indexes and cupboard lists

An index makes it easier to work with the collection. If files are arranged systematically, family and genus numbers can be obtained from literature sources such as Dalla Torre & Harms

(1958). For easy reference, make an alphabetical list of the relevant genera and their numbers.

A cupboard list is an alphabetical list of species in each genus, showing their numerical sequence in the collection. The numerical sequence is obtained from a revision or Flora in which the species are arranged phylogenetically and then numbered. The reference to the publication should be included on the list.

How to arrange specimens

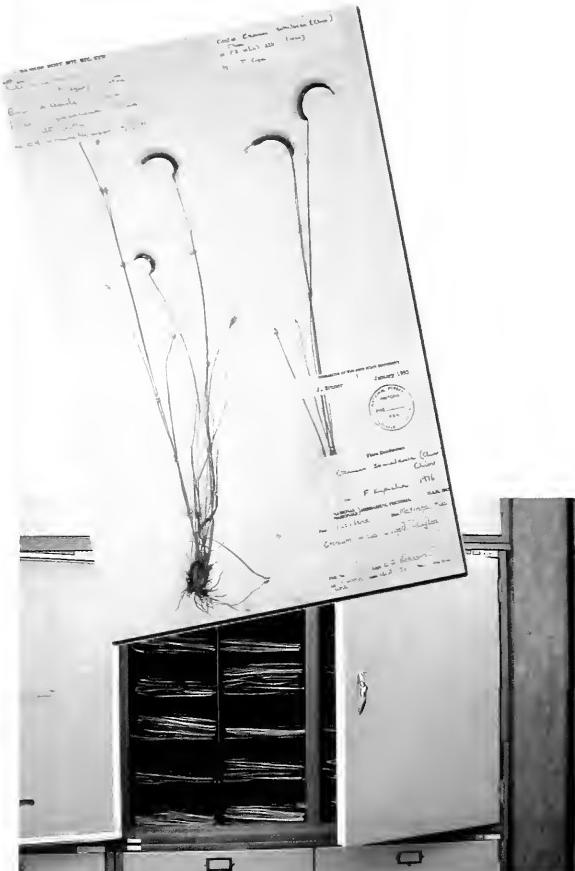
1. Sort species into filing order using either systematic (phylogenetic) or alphabetical order.
2. Subspecies, varieties, and formas follow files of the typical subspecies (where the subspecies name repeats the species name).
3. Place specimens named only to genus rank (for example, *Aloe* sp.) in a file marked *spp.* (= plural of species) at the end of the files for that genus.
4. File specimens of doubtful identification at the species level—mark with *cf.* (*confer* = compare), *aff.* (*affinis* = related to, has affinities with, but is not) and *sp. near* before the species name—with the main collection under the species that they most closely resemble.
5. File hybrid specimens in a separate cover, clearly marked as *hybrid*, at the end of one parent, cross-referencing the other parent's file to show that it exists.
6. Mark specimens that are as yet not described with *sp. A*, *sp. B* or *sp. 1*, *sp. 2*, or *sp. = Acocks 2135*. Place those representing the same taxon together in a species cover at the end, just before the main *spp.* files.
7. File naturalised species in the main collection, with the file labelled *Naturalised*.
8. Cultivated taxa can go into a separate cultivated plant collection, or into the main collection in files marked *Cultivated*.
9. Garden escapes (not yet naturalised), exotics, and aliens can be filed in the main collection.
10. Place types at the beginning of the genus to which they belong, in alphabetical order, for easy retrieval and for protection against frequent handling. Alternatively, house types separately from the main collection.

TIP For durability, lists can be placed in plastic bags. Using bags that are not permanently sealed makes later updates easier. Zip-closure bags are useful—they can be opened for adding notes but remain sealed otherwise.

Any new species described after publication and therefore not numbered, are added, in alphabetical order, at the end of the list for the genus.

The most recent synonyms should also be included in the list (in alphabetical order) as follows: the synonym is included in parentheses with an = sign preceding it, followed by the current name for example, (= *A. nitens*) *A. rupestris*.

Attach the list to the cupboard door near the genus, or mount it on a herbarium sheet and file it at the start of the genus.



TIP When filing each specimen, check that it matches the others in the file. Sometimes labels are switched in mounting. Be suspicious of needing a new species cover for one specimen.

Quick Guides

A Quick Guide is a reference collection that consists of one representative specimen (rarely more) of each taxon. The Guide is kept separate from the main collection and is an invaluable aid for identification. Even if the main collection is arranged alphabetically, the Quick Guide should be arranged systematically; in this way, similar taxa will be close to each other.

How to compile a Quick Guide

1. Choose either one specimen with "average" characters for each taxon or more if there is a wide variation.
2. File identification information in the first file of the genus. Such information includes keys, distribution information, and notes on important diagnostic characters. Illustrations of the range of variability of characters can also be incorporated. It can also be useful to write the main diagnostic characters and broad locality in pencil on the specimen.
3. Add cupboard lists to the Quick Guide.
4. For extra protection, place each specimen in a plastic bag; Quick Guide specimens are handled much more often than those in the main collection.
5. Don't use rare and type specimens. Photocopy these specimens and use the copies in the Quick Guide.
6. List or obtain photocopies or scanned images of specimens from other herbaria of taxa not represented in the collection, but which could occur in the floristic region dealt with by your herbarium.



A researcher doing a plant identification.

Computerisation

Computers have become indispensable in the modern herbarium and are used to write reports and articles, produce specimen labels, record loans, and to capture and store plant information. They can also be very powerful communication tools through the Internet, e-mail, and the World Wide Web.

Before any herbarium starts to computerise its specimen information, thought should be given to the purpose and long-term maintenance of a database. If the purpose is not clear or there is no long-term commitment to maintain the database, it is better to seek advice on whether computerisation would be of any value.

Information should not be captured indiscriminately. It is important that the database is structured correctly and planned carefully. Communicate with experts and use the correct software.

Advantages

Computerising a herbarium collection has many advantages:

- Computerisation enables the user to access large quantities of data, with the potential to expand analytical research.
- Once computerised, specimen data can be changed or corrected easily.
- It is simple to add additional fields to the database when needs change.
- Herbaria can be managed more effectively with maximum use of botanical information.
- Data can quickly be extracted in different formats to assist researchers and herbarium workers.
- It is a straightforward task to get statistics to aid herbarium management, for example, how many specimens there are in the herbarium or in a specific plant group.
- Distributions of plants are always a very popular output. If either quarter-degree or point data was captured, distribution maps can be produced with little effort using computer software such as ArcView or MAPPIT.
- Other outputs are also possible, for example, a list of species per quarter-degree grid square, a list of species in a genus, a list of plants collected by a specific collector, or a list of plants flowering in a specific period. This information facilitates planning for collecting trips, as it highlights areas and species that are under-collected.

**My computer keeps doing what I tell it to do,
not what I want it to do!**

Disadvantages

There are, however, also a few disadvantages associated with computerisation:

- Keeping up with new technology, maintenance of hardware and software, licensing, and virus protection are costly necessities.
- Staff training is costly and time-consuming.
- The process of computerisation is time-consuming.
- Constant quality control is needed. The information in the database can only be useful if data is captured accurately; therefore, the input and output have to be monitored continually.
- Database maintenance is dependent on long-term commitment from herbarium staff and takes much time.

The PRECIS system

One of the most important components of herbarium computerisation is to capture the label information of all specimens in the herbarium. For this purpose, southern African countries have access to a database system called PRECIS, an acronym for National Herbarium, Pretoria (PRE), Computerised Information System. This database stores information from herbarium specimen labels, thereby maintaining a comprehensive electronic record of the collections in a herbarium. This information is then accessible for manipulation in a variety of ways, such as the generation of maps, specimen labels, and checklists.

The PRECIS database has three components:

- Specimen PRECIS: specimen records and information
- Taxon PRECIS: plant names, with synonyms, and literature references
- Curatorial PRECIS: exchanges, loans, and dispatch lists

The Specimen PRECIS database is used to capture the collector label information of herbarium specimens. Information recorded by the plant collector on the original specimen label, as well as additional information (for example, type and voucher), is stored. This database is now widely used in Africa. An additional feature of the specimen database system is that specimen records entered by a herbarium can be made available to other herbaria using the same system. The database can be ordered from the National Herbarium, Pretoria, along with a manual (Prentice & Arnold 1998) of instructions on how to use PRECIS.

The Taxon PRECIS database stores information on plant taxa, for example, names and synonyms, as well as references to descriptions, treatments and illustrations of taxa. It can be expanded

to include various other sets of information on plant taxa, such as floristic data (flowering times, altitude, habit, habitat, plant height), which is generally coded and searchable, or descriptive data, which is not coded and is searchable on keywords only. Separate datasheets for medicinal, economic, or horticultural uses, for example, can be developed to add to the electronic data set.

The Curatorial PRECIS database keeps track of specimens that are sent out on loan or exchange programmes and specimens submitted for identification.

You can also generate detailed user-specified reports at the family, genus, and taxon levels, or for a single collector. Output constitutes all the information entered for each specimen (such as grid, latitude and longitude, collector's number, and date of collecting). Outputs currently available include listings of grid references for taxa from which computer-generated distribution maps can be produced, using the National Botanical Institute's MAPPIT programme. Draft or final specimen labels for mounting on specimen sheets may also be printed.

Geographical Information Systems

Geographical Information Systems (GIS) technology has the potential to expand the applications of botanical databases through processes such as overlay of collection site data with natural resource and political data. The botanical GIS allows spatial queries, a function that a herbarium database cannot perform independently. It would enable the identification of new areas to search for rare species, based on the occurrence of habitat characteristics matching those of known collection sites. In this way, it could become an important tool in studies of endangered species and conservation efforts (Rhoads & Thompson 1992).

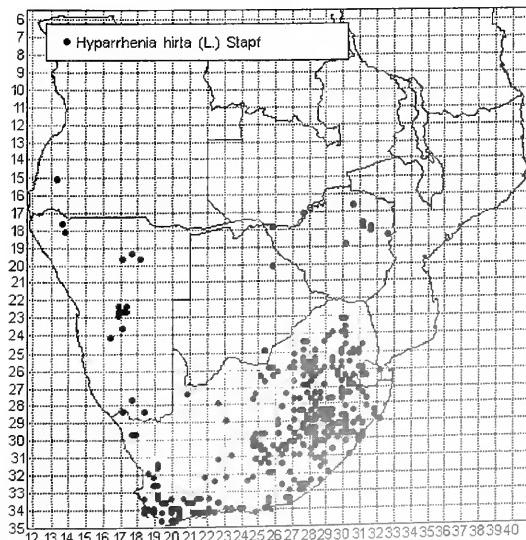
Because of highly variable locality information, there is much botanical data locked into databases that cannot be easily analysed using GIS. When locality is recorded using precise measurements, a variety of maps can be created and it is possible to overlay the distribution data with topographical, geological, or other environmental data. Precise distribution information, for example, decimal degrees, should be attached to computerised

P **T** **T** **GIS technology enables the user to capture, maintain, update, manipulate, analyse, and display geographically referenced information. A GIS consists of hardware, software, and geographic data.**

specimens where possible. Distribution information should be in one of the following formats: grid reference; degrees, minutes and seconds; or decimal degrees. If the specimen label only has a description of the locality, but no latitude-longitude information, a gazetteer or map should be used to find the precise locality. In the PRECIS Specimen Database, the corresponding quarter-degree grid reference is automatically inserted, once the longitude and latitude values have been entered. The quarter-degree grid reference of the specimen locality should only be entered when degrees, minutes and seconds, or decimal degree values are not available.

*LEGEND	
-	<i>Hyparrhenia hirta</i>
(L)	Stapf
1713DA	
1813BB	
1917BC	
1917CA	
2025BB	
2216BD	
2216DB	
2216DD	
2217AD	

Part of the list of grid references for *Hyparrhenia hirta*.



Distribution map of *Hyparrhenia hirta* generated using MAPPIT.

Data input

The following types of information on herbarium specimens can be computerised:

Locality refers to the exact position of a specimen and is recorded both descriptively and according to the map or grid reference. The closest reference point (such as nearest town or well-known landmark) and the precise locality of the specimen are usually recorded. This information is obtained from maps (1:250,000 or smaller) together with a GPS (Global Positioning System) instrument.

Habitat Information can speed up the process of finding a specific species in the database when used in combination with locality data. It is also useful for locating a rare species that needs monitoring. Habitat information from the database can also be incorporated in publications, as was done in *Grasses of southern Africa* (Gibbs Russell *et al.* 1990).

Collector Information is the most useful way of keeping track of a specimen.

Date of Collection can indicate flowering or fruiting times, because good herbarium material should be fertile (with flowers or fruit). Such information is useful for the timing of field trips, for example, when you need to collect fruit for a genus under revision. Flowering and fruiting times can also be included in a publication.

Collection dates play an important role in conservation work, as they may indicate species that should be considered for a Red Data List or for conservation planning. Possible habitat changes can be inferred from large discrepancies between collecting dates, or when a species appears not to have been collected for a long time. A case in point is *Prionanthium ecklonii*, first collected in 1775, next in 1975, and thereafter only twice in the 1980s, indicating a very rare species that may have disappeared from its former distribution range.

MAPPIT is a DOS-based programme that converts a list of quarter-degree grids, grids, or point data into a distribution map. Base maps for the entire African continent, as well as many individual African countries, are available. The programme can be obtained from the Database Manager, National Botanical Institute, Private Bag X101, Pretoria 0001, South Africa. A Windows-based version is being developed.

In addition, through analysis of collection dates, the date of introduction and the spread of weeds and other alien species can be determined.

Type Specimen records in herbarium collections give researchers an indication of which herbarium to apply to for the loan of types when doing research.

Data output

Once specimen data has been recorded in a database such as PRECIS, you can generate distribution maps, species lists, and gazetteers from the data.

Distribution maps

A grid reference or map is crucial for each specimen if the data is to be used to create distribution maps. Once this information has been recorded in the database, distribution maps for each taxon can be generated and these have many applications. Maps are like symbols or illustrations; there is no language barrier and information can be interpreted quickly.

Maps can be drawn on a national or regional basis, indicating the number of species or specimens per grid square. In addition to showing each herbarium how its collections are made up, such maps indicate areas that are under-collected and are invaluable in the planning of general collecting field trips.

Maps are also useful when doing identifications: if there is no record of the particular taxon in or near the locality of the specimen under consideration, it may mean the identification is wrong. One can see this at a glance when looking at a map. It can also indicate that the locality given, or the label attached, is incorrect. Points on a map that appear as outliers from the main distribution could mean that a particular specimen has been incorrectly named or encoded; this is useful for quality control of the collection and the information in the database.

In addition, maps are an invaluable source of information to scientists involved in research on specific taxa or groups of plants. For example, when a new species is published, maps are included to show the extent of distribution. Such maps increase the information available on the species being described and show possible geographical links with similar species.

Projects such as Threatened Species Programmes utilise Red Lists and conservation planning lists that also benefit from maps. By analysing distribution maps one can identify candidates that are possibly threatened by looking at the taxa that

appear to have a restricted distribution or a limited number of collections. Maps can be used as the starting point in conservation actions to see which areas may need to be conserved, and provide historical distribution of taxa whose range have become reduced or taxa that have become extinct. Moreover, weed distribution can be monitored through mapping. This helps with control and possible prevention of alien plant invasions, as the distribution maps alert botanists to areas where particular weeds are found.

Gazetteer

The computerised information can also be used to compile a gazetteer of place names by combining grid references and locality names. This can be a valuable product of PRECIS in countries where a gazetteer is not yet available.

Lists

Lists of species per grid can be generated on a national or regional basis. An indication of the biodiversity of an area can be obtained by listing all taxa recorded. Such an area can either be small and local—a National Park, for example—or regional, like the SABONET countries. Such lists can be used as the basis of checklists for collecting trips. Other types of lists include flowering times and collectors' names. Lists can also be generated on request for interested members of the public.

System maintenance

Technology changes at a rapid pace. Staff working with computers should be informed about software and should make a point of learning to use new versions of, for example, a word-processing programme. As new and updated software is required every few years, computers should be upgraded regularly. Components that can be upgraded include the hard disk drive and the motherboard. An extra CD-ROM drive can also be installed. It is therefore unnecessary to purchase new computers every time more advanced software is required.

If expertise is not available in-house, a good relationship with a reputable computer dealer is important as computers have be-

P **Making backups of all the information on your computer is the most important component in system maintenance. Regular monthly back-ups should be adequate. In addition, we recommend that computers are defragmented and optimised regularly using software such as Norton Utilities.**

come very specialised and not every herbarium worker has a keen interest in computer hardware.

Loans

One of the services that many herbaria offer is sending out specimens on loan to researchers all over the world. As a scientist, you can also request loans from other herbaria to help you in your work.

Selecting specimens to send out on loan

Unless the person requiring the loan has made special requests, we recommend that you select

- Only fertile material.
- Specimens representing the full range of variation in form, including flowers (both male and female if unisexual) and fruits. Include specimens with coppice shoots and shade forms.
- Specimens representing the full range of distribution: geographical area, altitude, and habitat type.
- Any unusual specimens—they may be hybrids or new species.

Once you have chosen the specimens, check that the herbarium name or stamp, the country, and locality are on every specimen. Also make photocopies of any drawings, letters, or notes that may be useful to the researcher.

Finally, in the herbarium, fill in a summary loan sheet, giving the following details:

- Date on which the loan was sent
- Researcher's name and institution
- Number of specimens of each taxon sent

File this sheet in the first file of each genus, or the family file if many genera are concerned. PRE uses a mounting sheet with a distinctive yellow band at the bottom for such lists. This serves as a record of the loan in the herbarium over and above the official records kept by the despatch office. Its presence will alert workers to specimens being absent and their space will be reserved.

Handling requests for loans

If possible, send all the material that is requested. If the entire collection of a species is requested, however, it is advisable to retain a few representative specimens so that identification services can continue. Some herbaria stipulate that only half the specimens of any one species may be lent at one time. Postage costs may also limit the amount of material being sent to an-

other institution. Remember that any repairs needed should be done before the loan is sent.

Pack the material carefully, with each specimen individually protected by a flimsy. Place a cardboard sheet at the bottom and the top of the pile, as well as between every 20 or so specimens. Strap the pile securely and wrap in waterproof and shock-absorbing material, such as bubble wrap. Place the wrapped pile in a reinforced mailing box to prevent the specimens being squashed and damaged. No more than 100 specimens should be placed in one box. Note type specimens are packed separately and sent via airmail.

A letter to the borrower should state the number of sheets or specimens on loan. In addition, the letter should include the conditions of the loan. Time limits may be imposed, but should not be too stringent—a year is adequate, with the possibility of renewal on request. A condition should be made that loaned specimens be annotated before they are returned, and that they be packaged very carefully to avoid damage in transit. Some herbaria have a policy of never lending types or historically important specimens. In such cases, it is convenient to have photographs of valuable specimens that can be supplied on request.

If the loan is not returned within the required period, send a letter to the loan recipient. When the loan is returned, promptly acknowledge the receipt of the loan and include confirmation of the number of sheets and of their condition. Decontaminate specimens before replacing them in the herbarium.

Requesting loans

If a researcher at your herbarium needs specimens from another herbarium, you can request such specimens on loan. Write a letter of request to the curator, specifying the family, genus, and species of the required specimens, as well as the synonyms under which the material might be filed. Geographic area of interest should also be stated.

Decontaminate the material as soon as it arrives. Examine the specimens for damage in transit to establish that the damage did not occur while the material was in your hands. If repairs are



Don't forget to select specimens from the spp. files (see page 44), since these may contain new species or interesting records that can be correctly named by the researcher.



NATIONAL
BOTANICAL
INSTITUTE

RESEARCH AND SCIENTIFIC SERVICES

The Compton Herbarium

Kirstenbosch Research Centre
National Botanical Institute
Rhodes Drive, Newlands, Cape Town
 Private Bag X7, Claremont, 7735
SOUTH AFRICA

T +27(021) 799-8800/ FAX: +27(021) 7614151
E-MAIL: beyers@nbict.nbi.ac.za
WEBSITE: <http://www.nbi.ac.za>

CONDITIONS FOR LOAN OF HERBARIUM SPECIMENS

Thank you for requesting our material on loan. We trust that it provides useful data for your research project. All research workers using this loan material are respectfully requested to observe the following conditions:

1. Loans are made only to approved botanical **INSTITUTIONS** and not to individuals, solely for the purpose of monographic and revisionary studies. The loan request should specify the scope of the work and whether material will be removed for anatomy, chemotaxonomy or palynology.
2. Loans are made for a **PERIOD OF 12 MONTHS** and should be returned at the earliest opportunity, preferably in their entirety. **TYPE SPECIMENS** must be returned within **6 MONTHS**. Application for the extension of loans should be made in writing, prior to the expiry date.
3. **LOANS MAY NOT BE TRANSFERRED** from one institution to another. In special cases written permission may be obtained from the Curator. Specimens may not be moved from the premises of the borrowing institute for study (e.g. to private residences).
4. A herbarium specimen is an **ARCHIVAL RECORD** which should be treated in a manner that will conserve it for future study. No existing writing, drawings, photographs, annotations, tickets, labels or determinavit labels already on the sheet may be removed, altered or defaced in any way.
5. Herbarium specimens should be handled with care and should be **STORED** under safe, dry and dust-free conditions in insect-proof cases. Type specimens should remain in their red-bordered covers except during actual examination.

Example letter: Conditions for loan of herbarium specimens.

6. If **DISSECTION AND THE REMOVAL OF PARTS** has been permitted by the Curator, this should be done judiciously. Material may be removed only when there is sufficient quantity to allow this.

If pollen or anatomical samples are removed, a small dated voucher label should be affixed to the sheet stating the purpose for which the sample was removed and by whom the study was undertaken. A duplicate voucher (such as a permanently mounted slide or in the case of electron microscopy, a photograph) could be placed in a labelled envelope attached to the sheet.

7. **ALL SPECIMENS BORROWED MUST BE ANNOTATED BEFORE THEY ARE RETURNED.** Please use small determinavit or confirmavit labels which are printed, typed or written in indelible ink. Commercial adhesive labels are not of archival quality.

When a previous annotation requires no change of name or authorship, the annotation may be in the form of a confirmation.

The annotation label should bear the name of the taxon and its author, the name of the annotator and the date of the annotation.

Specimens that cannot be accurately named, or those belonging to groups other than the ones under consideration, should be annotated as far as possible.

Annotation labels should be affixed so that they do not cover any printing, writing, or material on the sheet.

Labels designating type material should be affixed to all type sheets when these are not already present.

8. **PACKAGING AND POSTAGE REQUIREMENTS FOR RETURN OF LOAN.** Herbarium sheets should be held between boards securely strapped together and surrounded by waterproof and shock-absorbing material and placed in a reinforced mailing box. The box should be securely bound to avoid damage in transit. When returning a loan, local herbaria should register the parcel and overseas herbaria should clearly state that the material is for scientific purposes only with a NIL customs value.
9. Reprints of **PUBLICATIONS** based upon our collections are appreciated and should be addressed to: The Curator, Compton Herbarium, Private Bag X7, Claremont, 7735, Republic of South Africa.


NATIONAL BOTANICAL INSTITUTE

PRE LOAN DISPATCH LIST

Loan no: 03030

File no: 12/1/2

Date: 02/27/2004

Sent to: The Curator
 Compton Herbarium
 Kirstenbosch Research Centre
 NBI Kirstenbosch
 Private Bag X7
 Claremont
 7735 South Africa

From: The Director
 National Botanical Institute
 Private Bag X101
 Pretoria, 0001
 South Africa

No. of specimens: 372

For attention:**Taxa sent:** Campanulaceae**Description:** Herbarium specimens on loan

IMPORTANT: Please refer to loan conditions (appended separately)

* Check specimens when received

/ Check specimens before returning

LIST NO.	PRECIS NO.	COLLECTOR	COLL NO.	PLANT NAME	TYPE	*	/
1		GALPIN, E.E.	2265	Wahlenbergia galpiniae Schltr.	T	—	—
2		GALPIN, A.	2059	Wahlenbergia galpiniae Schltr.	—	—	—
3		MEDLEY-WOOD, J.	6677	Wahlenbergia grandiflora Brehmer	T	—	—
4		SCHLECHTER, F.R.R.	4601	Wahlenbergia grandiflora Brehmer	T	—	—
5		SCHLECHTER, F.R.R.	11126	Wahlenbergia lasiocarpa Schltr & Brehmer	T	—	—
6		SCHLECHTER, F.R.R.	11108	Wahlenbergia schlechteri Brchmer	T	—	—
7		SMITH, C.A.	80	Wahlenbergia sp.	—	—	—
8		GILLETT, M.C.	1074	Wahlenbergia sp.	—	—	—
9		HOUGHTON COLLEGE	5	Wahlenbergia sp.	—	—	—
10		GILMORE	9	Wahlenbergia sp.	—	—	—
11		MOGG, A.O.D.	9640	Wahlenbergia caledonica Sond.	—	—	—
12			P1196	Wahlenbergia sp.	—	—	—



NATIONAL
BOTANICAL
INSTITUTE

Our reference: _____

Date: _____

Dear Sir

REQUEST TO EXTEND A LOAN PERIOD

We would like to request an extension of the return of loan(s) no. _____
comprising _____ specimens of _____
for study by _____ of this institute for a further period of six/twelve months.

Thank you kindly

for Director Research: NBI

Example letter: Request to extend a loan period.

NATIONAL HERBARIUM
NATIONAL BOTANICAL INSTITUTE
PRIVATE BAG X101, PRETORIA, SOUTH AFRICA

Ref. 12/1/2

02/26/2004

The Curator
(Address)

OUTSTANDING LOAN

Dear Sir / Madam

According to our records the following loan is overdue:

Loan number: 03025
Sent to you: 07/10/2003
Attention:
Description: 364 Campanulaceae herbarium specimens
Returned to date: 0

We should appreciate the outstanding specimens being returned to PRE at the earliest possible opportunity. If they are still required for research purposes, please indicate this on the attached reply form and return it to us to request an extension of the normal twelve-month loan period.

If your records show that you have already returned this loan, please make an appropriate note on the reply form, and send it back to us so that we can try and locate the specimens in our herbarium.

Yours faithfully

Assistant Curator: Services

Example letter: Outstanding loan.

OUTSTANDING LOAN REPLY FORM

Ref: 12/1/2

The Curator
Compton Herbarium
Kirstenbosch Research Centre
NBI Kirstenbosch
Private Bag X7
Claremont
7735 South Africa

The Director
National Botanical Institute
Private Bag X101
Pretoria
0001
South Africa

Date: _____

With reference to loan number 03025, dated 10/7/2003.

1. Study of the material is now complete. All specimens will be returned within 6 - 10 weeks.

2. Part of the material is still required for further study, for which a twelve-month extension period is requested. The remaining specimens will be returned within 6 - 10 weeks.

3. All the outstanding specimens are required for further study and a twelve-month extension period is requested.

Additional remarks:

Signature _____

Designation _____

Example letter: Outstanding loan reply form.

UNIVERSITY OF CAPE TOWN

**Bolus Herbarium**

University of Cape Town
Private Bag
Rondebosch 7701
Republic of South Africa
Telephone: 650 3773
Fax: 650 4041

26 October 2001

The Curatrix
National Herbarium
National Botanical Institute
2 Cussonia Avenue
Private Bag X101
Pretoria
0001

Dear

RE: LOAN REQUEST

Dr _____ a fellow researcher of the Bolus Herbarium currently engaged in research in the Asclepiadioideae - Ceropogiaeae (Apocynaceae), would like to borrow the material in your herbarium of the genera *Ceropégia* and *Brachystelma* for a phytogeographic account of these genera.

Dr _____ would also like to borrow your material of the genus *Tylecodon* for a revision of this taxon in conjunction with a broader project on the phylogeny of the southern African Crassulaceae.

Whilst in our care the specimens will be kept in archival conditions at all times.

With thanks
Yours sincerely

'OUR MISSION is to be an outstanding teaching and research university
Educating for life and addressing the challenges facing our society'

Example letter: Loan request form.



NATIONAL
BOTANICAL
INSTITUTE

COMPTON HERBARIUM
Kirstenbosch Research Centre

NOTE: In 1996, the Stellenbosch Herbarium (STE) was merged with the Compton Herbarium (NBG).
All STE collections should now be cited under NBG.

RECEIPT FOR HERBARIUM SPECIMENS (NBG & SAM)

To:

Ms
National Herbarium
National Botanical Institute
Private Bag X101
PRETORIA
0001

From:

The Curator
Compton Herbarium (NBG)
& South African Museum Herbarium (SAM)
National Botanical Institute, Kirstenbosch
Private Bag X7, CLAREMONT 7735
Cape Town SOUTH AFRICA
Tel: (021)799-8800/Direct 799-8769 Fax: (021)761-4151
E-mail: roux@nbict.nbi.ac.za <http://www.nbi.ac.za>

Date: 11 November 2003

FOR IDENTIFICATION

NUMBER OF PACKAGES 1

NAMED SPECIMENS RETURNED

SURFACE MAIL

GIFT/EXCHANGE

AIR MAIL

BY HAND

Details of Specimens:—

Specimens (Crassulaceae) for identification sent by Dr _____ : (University of Kansas)

Collections Manager

We are sending you herbarium specimens as indicated above. Please verify the contents of this consignment upon its arrival and acknowledge receipt by signing the GREEN FORM and returning it to The Curator, Compton Herbarium, National Botanical Institute, Kirstenbosch Research Centre, Private Bag X7, CLAREMONT 7735, Cape Town, South Africa. Retain the WHITE FORM for your records.

Signed:.....

Date:.....

PLEASE SIGN AND RETURN.

Example letter: Receipt for herbarium specimens.



NATIONAL
*B*OTANICAL
INSTITUTE

Our reference: _____

Date: _____

Dear Sir

HERBARIUM EXCHANGES AND GIFTS

Thank you for the _____ you sent us.

We appreciate receiving the specimens as _____

Yours sincerely

for Director Research: NBI

Example letter: Herbarium exchanges and gifts.

How to re-file returned loans

When a loan of specimens is returned and has been checked off on the loan list, it has to be re-filed in the herbarium. The specimens should now all have a *det.* or *conf.* label, giving the plant name, date, and the researcher's signature. (The revision based on the loan will probably not yet have been published.) These authenticated specimens can be placed at the front of files to assist identifications.

No Name Changes

These specimens can be returned to their original files.

Names Changed to Existing Names

1. Do not change the name on the original label—the date on the *det.* label should indicate the latest name.
2. Make labels for specimens that have been seen by the researcher, but are without *det.* labels. Include the name of the researcher and the date on which it was collected.
3. Enter name changes into the database.
4. If the Quick Guide specimen has not been authenticated, update the Quick Guide using an authenticated specimen.
5. Re-file the specimens.

New Names

New, unpublished species names are referred to as *ined.* (*in-edita* = unpublished writings) until they are published. Once the name has been published, it may be necessary to update other information about the specimens.

1. Place all specimens of each *ined.* taxon in a new species cover, labelled with the new name and the word *ined.*
2. File specimens alphabetically at the end of the genus, before the *spp.* files.
3. Quick Guide specimens of *ined.* taxa can be made, but mark them clearly as such.
4. *Ined.* specimens can be used for identifications by matching, since descriptions and keys will not yet have been published; however, identified specimens must be clearly marked as *ined.*

needed, do them immediately. Verify the number and sequence of the sheets, and acknowledge receipt of the loan in writing.

Specimens on loan from another institution are a special responsibility:

- Store the specimens under dust-proof and insect-proof conditions and handle them carefully.
- Obtain permission before detaching or dissecting parts of a specimen.
- Place dissections in envelopes on the sheets.
- Never modify the original label.
- Place labels confirming or re-identifying a name as close as possible to the main label. *It is as important to confirm a previous identification as it is to give a new name.* Record the date of annotation, and use your full surname, not merely your initials.
- If the herbarium providing the loan does not allow the researcher to attach labels to the specimens, send the labels with the collectors name and number separately; the herbarium staff can then attach the labels themselves.
- Comply with any other conditions made by the loaning herbarium.
- Acknowledge loans in published papers, and send reprints to the institutions that lent specimens for the study.
- Return the loan when the stated period expires, unless an extension is granted. If you require an extension, apply in writing at least a month before the expiry date.
- When returning the loan, confirm the number and sequence of sheets. Pack the loan carefully—damage in transit is often due to careless packing. For more information on packing specimens, see “Handling requests for loans”.

Removing samples from specimens

Every herbarium needs to have a policy dealing with requests for research material to be used, for example, for anatomy, palynology, phytochemistry, cytology, DNA studies, and so on. Parts of specimens have to be removed to provide material for such requests. Use the following questions as guidelines in formulating your herbarium’s policy:

- Are the herbarium specimens regarded as archival records, not to be tampered with, or are they free to be used as resource material for taxonomic research?
- How rare is the taxon concerned?
- Can one allow material of common taxa to be removed?
- Is the researcher merely saving time and effort by having specimens sent to them or would the researcher have great difficulty coming to collect their own material?
- Has the herbarium material been treated in some way (for

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If you don't have time to do individual packing of the loan straight away, put the specimens in temporary paper folder by species and store them in a cupboard. This will make it easier to sort them out later.

example, poisoned or microwaved) that may affect research results?

- Will the study contribute to the taxonomy of the plant group?

If removal of material is allowed, keep the following points in mind:

- Do not remove material from type specimens and other historical specimens.
- Attach a small label to the specimen, giving notice of the detachment (plant part, name and location of the recipient, and date).
- Advise visitors on your herbarium's removal policy; visitors should not remove parts of specimens without permission.

Remounting and repairing specimens

Specimens that are handled often may become detached and require re-strapping or re-glueing. This should be done as soon as the problem is noted. Remounting and repairing may also be necessary for the following reasons:

- If specimens are mounted on board of inappropriate quality or size, or on board that has become damaged or fragile with age.
- If two different gatherings have been mounted together, either deliberately, as practised in the past, or accidentally because they have not previously been recognised as a mixture.
- If specimen labels start to fade—labels written in non-archival ink fade with age.
- Insect damage.

Use the following guidelines when remounting and repairing specimens:

- When two different species mounted on one sheet are divided, it is important that divided parts have cross-references to each other, stating "Separated from—". This is a safeguard if an error is made when dividing a sheet, for example, by leaving the wrong label with the specimen.

- When a sheet is divided, the collector's number is annotated by adding alphabetical letters: one remains as *Smith 3486* and the other becomes *Smith 3486A*. Note that a cited specimen retains the original number.
- Preserve all labels and notes written directly on the mounting board.
- Replace a faded or fragile label with a newly copied version, but remember to keep the original in an envelope. Glue the envelope to the mounting board, preferably in the top left-hand corner.
- When remounting a strapped specimen, remove the specimen by disengaging the gummed paper straps with forceps; remove the label or cut around it; then remount the specimen and glue the original label to the new mounting board.
- When remounting a glued specimen, detach the specimen from the sheet only if it can be done without harming the specimen. Otherwise, cut the sheet around the specimen and label(s), and remount the entire cut sheet on a new sheet.
- If only part of the specimen has detached from the sheet, there is no need to remount the specimen in its entirety: repair it by glueing or strapping the plant to the original board.
- If the mounting board is of good quality, but too small or too light, just glue the board to a sheet of the appropriate size and weight.
- If insects have damaged the specimen, clean by lightly brushing away powdered parts and treat immediately (see "Treating infestations"). Make a note on the specimen that it has been treated, the name of the poison used, as well as the date on which it was treated.

Duplicates

Duplicate specimens provide extra material to send to other herbaria either as gifts, or as exchange material. If possible, each duplicate specimen should have the complete range of stages represented in the original collection. Sterile or incompletely named specimens should not be sent to other herbaria. Duplicate specimens are usually sent unmounted. ▲



herbarium pests

*If we can't see the object,
we look for its effect.*

— Peacock

One of the most serious problems faced by herbarium staff, especially in tropical regions, is damage to specimens caused by insects. Pests that are often encountered in herbaria include cigarette beetles, cockroaches, rats, and fish moths, of which the cigarette beetle, *Lasioderma serricorne*, is the most destructive in this dry habitat. However, at some herbaria, located in a more humid and tropical climate, the most problematic pest is the psocid booklouse *Liposcelis bostrychophilus*.

Preventing insect damage

Freezing

The simplest method of ensuring that no contaminated material is brought into the herbarium is to freeze all new accessions *after drying*. Some insects can survive short periods of freezing, so the specimens should be frozen at -18°C for at least 48 hours.

Microwaving



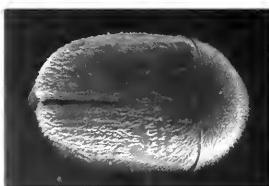
A specimen damaged by the cigarette beetle.



Always keep a lookout for insect damage. If you detect such damage, treat the specimen immediately. Clean by lightly brushing away powdered parts. Make a note on the specimen that it has been treated; stipulate the name of the poison used, and the date on which it was treated.



Adult; side view



Lasioderma serricorne viewed from top



Lasioderma serricorne from below

Specimens may also be microwaved, but this method may adversely affect the chemistry, DNA, and pollen, rendering them inadequate for research purposes. On the other hand, microwaving is quick, cheap, and safe, although only a few specimens can be microwaved at a time. Keep the following guidelines in mind:

- Microwave ovens cannot be used for fresh specimens—they may explode.
- Plants containing volatile oils (such as Rutaceae) will burn if microwaved.
- Be very careful to remove any metal objects, for example, staples or cigarette foil, which will cause sparks.
- Hall (1981) recommends 75 seconds of exposure was needed

to kill insects in parcels up to 50 mm thick, and two minutes for parcels 150 mm thick; this will, however, depend on the power output of the microwave oven.

- Do not microwave the specimens for too long or they may ignite.

Living plants

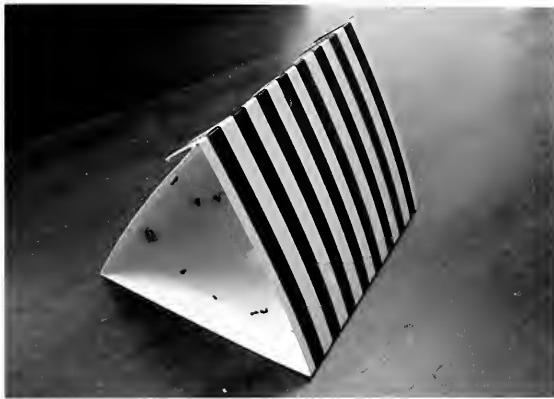
Fresh specimens do not pose a threat to dry collections: the insects that are found on living plants usually do not eat dead plants. It is better, however, not to bring a living potted plant into the herbarium, as psocids and other pests may inhabit bark litter.

Monitoring

Lasioderma traps are commercially available and are useful for monitoring cigarette beetle densities. The triangular trap has a sticky inner surface and a small vial of pheromones in the centre. Beetles are attracted by the pheromones and trapped by the sticky surface. The traps act as an infestation-warning device so that increased numbers of the beetle can be noticed before too



For the most effective freezing, specimens should be loosely packed in an open cage, or tied in a loose bundle to ensure that the cold penetrates to the centre of the stack.



Lasioderma trap.

much damage is done. It must be noted though that it is *not a means of prevention*.

Humidity control

High humidity can encourage proliferation of pests, especially cockroaches, fish moths, and booklice. If the humidity of the building can be maintained below 50% by installing air-conditioning, infestations should not occur. An alternative is to put a desiccant, such as silica gel, inside the herbarium cupboards. The gel, however, would have to be replaced or dried every

How to prevent insect infestations

Step 1: Start Clean

- Organise thorough fumigation of all areas where specimens are handled and stored.

Step 2: Prevent Insect Entry

- Seal any openings where insects may enter.
- Install insect screens on all windows.
- Keep windows and cabinet doors closed when not in use.

Step 3: Stay Clean

- Keep herbarium cupboard doors closed.
- Never bring potentially contaminated material into the herbarium.
- Avoid contamination: no eating, smoking, wet or muddy gumboots, or umbrellas in the herbarium.
- Monitor continuously.
- React immediately when you spot an infestation.

three months. This procedure is therefore labour-intensive and costly.

Treating infestations

In spite of preventative measures, there may still be infestations. We urge you to consider using toxic methods of control and eradication **only if no other method is successful in preventing infestations**. Many chemicals that have been used in the past and are still advocated in the literature, have been taken off the market, or are no longer regarded as safe methods. Specialist advice must be sought before any chemical methods are used. Never even use a commonly available spray insecticide without taking precautions. Also, remember that it is possible that chemical treatment may adversely affect specimens, and the specimens' use for research purposes, for example, DNA studies.

Fumigation

Fumigation by a registered pest control company is the most effective method of dealing with herbarium pests. Yet, even in the case of fumigation, the herbarium is guaranteed to be insect-free only during and directly after treatment. For effective control, fumigation should take place regularly at intervals of six to twelve months.

At present, only methyl bromide is effective against both adult beetles and eggs. The poison is applied in a single treatment and is therefore least disruptive to herbarium staff. Other chemicals are effective against adult beetles only and the treatment generally has to be repeated after two weeks. For more information on the use of these chemicals, specialist advice should be sought.

Localised treatment

Commercially available insect sprays contain dichlorvos, which is effective against live insects. It must be applied regularly as a space or surface spray, or "room fogger". Staff should wear adequate protective masks when administering the treatment, and no one should be allowed into the fumigated rooms for a 48-hour period after treatment. Individual specimens that are infested may be sprayed directly with a dry insecticide spray.

WARNING

Caution! Fumigation is potentially harmful to herbarium staff. No one should be allowed into the herbarium for a 48-hour period after treatment. Specialist advice MUST be sought before any chemical methods are used.

WARNING

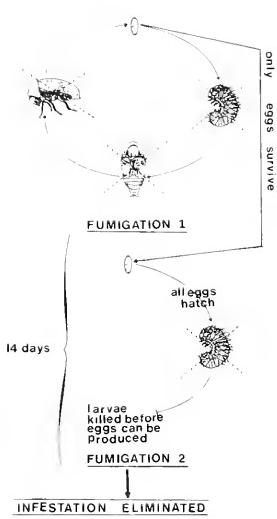
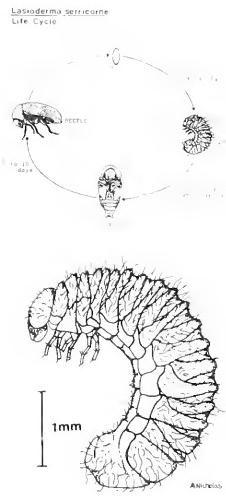
If there are poisoned specimens in your herbarium, place each specimen in a sealed clear plastic bag to prevent accidental contamination and poisoning.

Non-volatile insecticides, such as a barium fluorosilicate, starch and glue mixture, can control fish moth infestations when painted beneath the shelves, or on the back of compartments of wooden herbarium cupboards. Silica aero gel mixed with pyrethrin has been used successfully in inaccessible places, such as behind panelling or under cupboards.

Not recommended

In the past, fumigants such as naphthalene (mothballs) were placed in specimen cupboards. These are ineffective, however, and people working closely with specimens are exposed to the harmful effects of the chemicals. If these fumigants were used, staff would need to work in well-ventilated conditions, and unless the windows are covered with insect screens, it would be counter-productive to do so, as insects would be free to enter the building.

Other unsatisfactory techniques include coating specimens with mercuric chloride or a weak solution of lauryl pentachlorophenate (LPCP) in turpentine. However, LPCP is not dependably effective and mercuric chloride releases mercury vapour, which is very harmful to people and to the environment. ▲



Specimen covered with DDT.

1970

CHAPTER /

scientific curation

Province: Cape
Collected by: Col.
No. 334 - *Crassula*
17/9/50 - Slips were taken
Plants could be found
The height of 5 feet
Alt. Anno 3168

368
Crassula barbata Thunb.
Matjiesfontein, Cape.
7/1/51 No. 401

*Without taxonomy to give shape to
bricks, and systematics to tell us how to
put them together, the house of biological
science would be in a sorry jumble.*

— Robert May

The quality of the specimens and label information, filed in the herbarium, determines the scientific value of the herbarium collection. Properly prepared, well-mounted, and scientifically curated herbarium specimens can survive for hundreds of years and remain scientifically valuable.

A sound knowledge of taxonomy and botanical literature is needed to enable identification and curation of the collection, so that the herbarium collection can be maintained according to the most recent taxonomic revisions.

Taxonomy and nomenclature

Plant taxonomy is “the science that includes *identification*, *nomenclature*, and *classification* of plants” (Lawrence 1951).

- **Identification** is the naming of an organism by reference to a known plant or description.
- **Nomenclature** deals with applying the correct scientific name to a known plant, according to a nomenclatural system. This naming is regulated by rules in the International Code of Botanical Nomenclature (ICBN).
- **Classification** (as a process) is the production of a logical system of categories, each containing any number of organisms with shared characteristics, which allows easier reference to its components (kinds of organisms).

Rules for naming plants

To be accepted by the ICBN, plant names have to be *effectively* and *validly* published to be *legitimate* and correct.

- **Effectively published** means published in printed form and made available to the public, or at least to a botanical institution.
- **Validly published** means the name was published in an approved form and accompanied by a description or reference to such a name.
- **Legitimate names** are those that follow all the rules.

Plant names

Plant taxonomy organises plants into a hierarchical classification system with the following ranks: families, subfamilies, tribes, subtribes, genera, subgenera, sections, species, subspecies, va-

rieties, and forms. Not all ranks are present in every classification; for example, a species may not have a variety, subspecies, or forma. All ranks are written in Latin or in latinised form, according to the rules of the ICBN.

The name of a species consists of two words, called a *binomial*, for example, *Poa annua*. The first part of the binomial is the name of the genus or *generic name*, for example, *Poa*; the second part is the species name or *specific epithet*, for example, *annua*.

The name of a family is usually based on the name of the type genus, for example, Poaceae from *Poa*. However, it is also acceptable to follow the older system that was in general use, for example, Compositae instead of Asteraceae, Leguminosae instead of Fabaceae, and Gramineae instead of Poaceae.

The genus, as well as all the ranks under it, are written in *italics* or underlined script. The genus name is capitalised, whereas the species name and other lower ranks start with a lowercase letter, for example, *Aristida scabrilvalvis* subsp. *contracta*.

Authors

A plant name, when written in full, is followed by the author’s name or authors’ names. The author is the person who first validly published that name, for example, *Leersia denudata* Launert was first published by Georg Oskar Edmund Launert, and *Eragrostis acraea* De Winter by Bernard de Winter. (Note that author names are not italicised.)

Often the author name will be abbreviated, for example, in *Aloe* L. the “L.” refers to Linnaeus. Brummitt & Powell (1992) provided a standard work for the abbreviation of author names. All herbarium workers and taxonomists are encouraged to use these standardised abbreviations. There is also an online version available at www.ipni.org/ipni/author_query.html.

If a species is moved to a different genus, the author’s name is placed in parentheses, followed by the name of the author who made the new combination, for example, *Radinopiphon leptostachya* (Baker) N.E.Br. John Gilbert Baker first published this species in the Iridaceae as *Lapeirousia leptostachya* Baker, but Nicholas Edward Brown later transferred it to the new genus Radinopiphon.

“Ex” is used to connect the names of two persons, the second of which validly published a name that was proposed—but not validly published—by the first. It is permissible to omit the *first name*, although for clarity both authors are usually cited in Floras or formal checklists. An example is the grass species *Agrostis montevidensis* Spreng. ex Nees: Sprengel proposed the name—



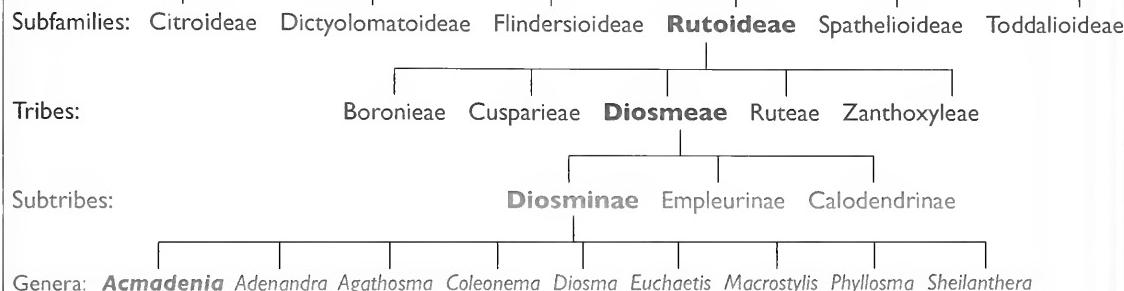
A useful reference to the endings of taxa:

Family: -aceae

Subfamily: -oideae

Tribe: -eae

Subtribe: -inae

FAMILY:**RUTACEAE**

Example of a hierarchical classification scheme.

STRELITZIA 10 (2000)

645

- 1a Plants terrestrial without pseudobulbs or corms, frequently with root tubers; very rarely growing on trees or rocks but then always having fleshy root tubers; leaves thin and soft, deciduous; anther erect, horizontally reflexed or pendent, not incumbent and not operculate; pollinia almost always sessile:
 2a Anther erect and subequal to rostellum; plants terrestrial or occasionally epiphytic, without root tubers..... Subfamily SPIRANTHOIDEAE:
 3a Leaves convolute, soft-herbaceous, often arranged ± rosette-like; inflorescence terminal Tribe CRANICHIDAE
 3b Leaves plicate; stems reed-like; inflorescences lateral or terminal Tribe TROPIDIACE (Corymborkis)
 2b Anther erect, horizontally reflexed or pendent and rostellum much shorter than anther; root tubers almost always present; plants terrestrial or rarely epiphytic Subfamily ORCHIDOIDEAE:
 4a Anther erect or suberect; median sepal unspurred; petals not clawed and fimbriate; lip often spurred, always without large appendage Tribe ORCHIDAE
 4b Anther horizontally reflexed or pendent; very rarely secondarily erect or suberect but then either median sepal spurred and large lip appendage present or petals clawed and fimbriate Tribe DISAE
 1b Plants epiphytic, epilithic or terrestrial, rarely lianas, frequently with corms or pseudobulbs but not with root tubers; leaves thin and soft, leathery or succulent; anther incumbent or rarely suberect, operculate; pollinia soft-mealy, sessile or hard and waxy..... Subfamily EPIDENDROIDEAE:
 5a Pollinia soft and mealy or sessile:
 6a Pollinia 8, soft, but clearly defined Tribe ARETHUSEAE (Calanthe)
 6b Pollinia 2 and sessile, or mealy and ill-defined:
 7a Terrestrial plants with 1 green leaf that develops after the flowers; plants arising from subterranean tubers; pollinia 2, sessile Tribe NERVILLEAE (Nervilia)
 7b Plants not as above:
 8a Saprophytes; pollinia 2, sessile Tribe GASTRODIEAE
 8b Lianas with green stems; pollinia soft and mealy Tribe VANILLEAE (Vanilla)
 5b Pollinia firm or hard, not sessile:
 9a Pollinia naked, without caudicles and stipes; sometimes with viscidia:
 10a Inflorescence terminal; plants with or without pseudobulbs, terrestrial or epiphytic Tribe MALAXIDAE
 10b Inflorescence lateral; plants with pseudobulbs, epiphytic Tribe DENDROBIEAE (Bulbophyllum)
 9b Pollinia with caudicles, often with viscidia and stipes:
 11a Plants monopodial Tribe VANDEAE
 11b Plants sympodial:
 12a Plants mostly terrestrial; if epiphytic then with long fusiform leafy pseudobulbs and large yellow resupinate flowers with brown blotches Tribe CYMBIDIACE
 12b Plants always epiphytic; flowers small to medium-sized and not resupinate Tribe EPIDENDRÆA (Polystachya)

Example of a key (from Leistner 2000).

by writing it on the label of the specimen, mentioning it in an article, or even suggesting it in a letter—but did not publish it validly. Subsequently, Nees von Esenbeck published the name validly.

"In," on the other hand, is used to connect the names of two persons, the second of which was the editor, or overall author, of a work in which the first was responsible for validly publishing a name. In this case, the opposite rule is applied: for the sake of brevity, the *second name* may be omitted. An example of this use is *Tricholaena* Schrad. in Schult.—here Schrader validly published the genus name in a publication by Schultes. The name is, however, often cited as *Tricholaena* Schrad.

Type specimens

A name is permanently attached to a taxon by means of a type specimen (or sometimes an illustration), which is the specimen (or illustration) used for the original description. There are various kinds of type specimens:

- **Holotype:** Specimen designated by the author as the type specimen.
 - **Isotype:** Duplicate of the holotype.
 - **Lectotype:** Specimen chosen to act as a type from the syn-types.
 - **Neotype:** Specimen chosen to act as a type when the original material has been lost.
 - **Syntype:** Any one of two or more specimens cited by the author when no holotype was designated, or any one of two or more specimens simultaneously designated as types.
 - **Topotype:** A specimen of a named taxon collected, usually later, from the original type locality, or from the area where the species was described.
 - **Iconotype:** An illustration used by the author when no specimen was available.

Descriptions

For a plant name to be valid, it needs to be published with a description. The description consists of the following parts:

- An obligatory diagnosis in Latin, describing the main characters that distinguish that species from other, similar, species.
 - An optional, full description in an international language.

The descriptions are often followed by a discussion of certain characters and further comparisons with other species. The geographical distribution and a list of some or all of the specimens seen are also given. Many specimens seen by the author are not cited, because of limitations imposed by the journal; these are often available from the author on request.

T I P Types are extremely important specimens and should be handled as little as possible and with utmost care. They have to remain in a well-preserved state for future generations of botanists to use in defining the concepts of particular taxa.

Taxonomic publications

A taxonomic publication can take one of several forms:

- **Checklists** are simply listings of plants of a specific area, sometimes with brief notes.
 - **Brief Latin diagnoses** accompany a slightly more expanded list of names.
 - **Descriptions of new taxa** are complete and often contain illustrations.
 - **Revisions** treat a family or genus in a specific smaller geographical region, or involve only part of the taxon.
 - **Monographs** are major revisions that deal with a whole family or genus on a worldwide basis.
 - **Floras** have descriptions, keys, and illustrations of all or some of the plants of a particular area, for example, a nature reserve, country, or subcontinent, or any designated area.
 - **Field guides** aim to give easily observable characters in the field, usually with short descriptions, and often illustrations, of the most common plants found in the area.

Identifying specimens

Identification should be done using keys and descriptions as a first step, followed by comparison with authenticated material. Matching, which is using comparison as a means of identification, is not ideal *when used on its own*, as it does not necessarily lead to correct identification. This may happen because:

- Specimens used for comparison have not necessarily been identified correctly.
 - Different species may be morphologically similar.
 - Sometimes characters separating species are not immediately obvious, but are highlighted in keys.
 - You may be trying to identify a species not yet in the collection.

Equipment and materials

- Keys, descriptions, and glossary.
 - Dissecting microscope or hand lens. A long-arm microscope allows you to examine mounted specimens. A black microscope stage is useful for identifications, especially for grasses.
 - Dissecting needles, scissors, and forceps.
 - Small and large rulers for measuring. For some groups such

as bryophytes and grasses, you will need a micro-measuring device, such as an ocular micrometer.

- Identification is made easier by restoring flowers and other plant parts to their approximate original form. This can be done by boiling the material in water until it is soft. An alter-



Different hand lenses.



Dissecting microscope used for plant identification.

T I P

Try using a small black or white ceramic tile when working under the microscope—the tile is easy to move around and you won't damage the microscope stage with your dissecting tools.

native, quicker method is to soak the material in "Windolene" (a window cleaner), or an equivalent ammonia-containing liquid for a few minutes.

- Petri dish or glass slide for laying out reconstituted material.
- Small paintbrush for teasing out delicate flowers or brushing off scattered pollen when looking for glandular hairs on flowers.
- *Det.* and *conf.* labels.
- Archival ink pen.
- Gummmed paper and envelopes for mounting dissected flowers.

T I P

When using a hand lens, move the object to be viewed, rather than the lens.

How to identify a specimen using a key

Keys are found mainly in floras, revisions, and monographs. It is useful to have a glossary handy when using a key. Generally, a key is an orderly arrangement of a series of contrasting or directly comparable statements, usually paired. Each pair, or couplet, offers contrasting possibilities in characters, called leads.

1. Read both leads of a couplet before making a choice about which one to follow.
2. Wherever possible, measure or observe several required structures before deciding.
3. If you cannot decide, for example, when the specimen does not show certain characters, follow both leads and check whether the next lead describes characters present in your specimen.
4. Eventually, you will reach a lead giving the taxon name. Now check herbarium specimens and descriptions of that taxon.
5. If the plant does not key out, try identifying by matching and reading species descriptions. If it is not possible to identify the specimen, it may possibly be a new record for that area, an unusual variation, a new species, or in a different genus. Some keys are old, and do not have all the known species of the genus.

When you have identified a specimen by means of a key and description only, without matching, you should add the words *e descr.* or *ex descr.* (*ex descriptione* = from the description) on the *Det.* label.

T I P

Make notes on the characters of the plant and the steps you have followed in the key, in case you have to start again.

Keep notes on diagnostic characters and distribution with Quick Guide specimens to make identification easier.

How to identify a specimen by matching

1. Consult the Quick Guide and select the species closest in both appearance and distribution to the unknown specimen.
2. Compare your specimen with material from the main collection. Take special note of other material from the same area. There may be a wider range of form in that species than is shown by the Quick Guide.
3. Read the description to ensure that it matches the unknown specimen.
4. Check that the distributions correspond.

Note: Matching specimens should *never* be the *only* procedure used to identify specimens.

Library and literature

Taxonomic literature is essential in a herbarium. It is used to

- Organise the herbarium collection
- Assimilate new species
- Facilitate name changes and taxonomic revisions
- Obtain keys and descriptions for identification

The herbarium staff should scan all new publications to keep informed about research concerning the flora of their region.

If books and journals are not locally available, affiliations can be arranged with inter-library network systems, such as the South African-based TISAB and SABINET, through which interlibrary loans can be requested. Interlibrary loans are subject to strict copyright legislation and are becoming increasingly expensive. Despite the cost, it is still more economical to link with an interlibrary network system than to subscribe to a wide range of taxonomic literature, as the cost of subscriptions escalates annually.

Most of the larger regional libraries, such as the NBI's Mary Gunn library and some university libraries are linked to regional or international search facilities. Should you not have access to search facilities, photocopies of essential reading material can be requested from these libraries.

Recommended herbarium literature

The two most essential literature references are a Flora of your area or nearby surrounding areas and a dictionary of botanical terms.

The following Floras and checklists are indispensable when working with plants from the southern African region:

- *Flora of southern Africa*
Includes South Africa, Swaziland, Lesotho, Namibia, and Botswana.
- *Flora of Tropical East Africa*
Includes countries such as Kenya, Uganda and Tanzania.
- *Flora of Tropical West Africa*
Countries such as Nigeria, Ivory Coast, etc.
- *Flora zambesiaca*
Includes Zambia, Zimbabwe, Malawi, Mozambique, and Botswana.
- GERMISHUIZEN, G. & MEYER, N.L. 2003. Plants of southern Africa: an annotated checklist. *Strelitzia* 14. National Botanical Institute, Pretoria.
Enumeration of species and subspecific taxa that occur in *Flora of southern Africa* region.
- LEISTNER, O.A. (ed.) 2000. Seed plants of southern Africa: families and genera. *Strelitzia* 10. National Botanical Institute, Pretoria.
Descriptions and keys for all families and genera that occur in the *Flora of southern Africa* region.
- LEISTNER, O.A. (ed.) 2004. Seed plants of south Tropical Africa: families and genera. *SABONET Report* No. 26. SABONET, Pretoria.
A supplement to Leistner (2000), this book provides keys and descriptions for all families and genera that occur in the southern African countries outside of the *Flora of southern Africa* region.

We also recommend the following publications:

- *AETFAT Index* (1953 to date). [Association pour l'étude

- taxonomique de la flore d'Afrique tropicale] Deals with tropical African names of flowering plants of all ranks.
- BRUMMITT, R.K. & POWELL, C.E. (eds) 1992. *Authors of plant names: a list of authors of scientific names of plants, with recommended standard forms of their names, including abbreviations*. Royal Botanic Gardens, Kew. A comprehensive list of authors of plant names, with their accepted abbreviations and dates of birth and death.
 - BRUMMITT, R.K. 1992. *Vascular plant families and genera*. Royal Botanic Gardens, Kew. A listing of the genera of vascular plants of the world according to their families as recognised in the Kew Herbarium, with analysis of relationships of the flowering plant families according to eight systems of classification which are summarised. Compiled by R.K. Brummitt, in collaboration with the Kew Herbarium staff and with the assistance of botanists elsewhere. Gives accepted generic names and selected synonyms with their accepted families. Also lists the accepted genera in each family.
 - FRODIN, D.G. 1984. *Guide to standard Floras of the world*. Cambridge University Press, Cambridge. An annotated, geographically arranged systematic bibliography of the principal Floras, enumerations, checklists, and chorological atlases of different areas.
 - HOLMGREN , P.K., HOLGREN, N.H. & BARLETT, L.C. 1990. *Index herbariorum*. International Association for Plant Taxonomy, New York Botanical Gardens, Bronx, New York. Gives information of world herbaria and their staff and publications etc. Important for communication and arranging loans. Includes herbarium acronyms (for example, K = Kew), often found in taxonomic literature and on labels.
 - *Index Kewensis* (1893 to date). A comprehensive work with many supplements, lists all binomial and generic names of flowering plants from Linnaeus (1753) onwards, and all names at rank of family and below from 1971. Because it does not always follow current rules on nomenclature, it should be used as a guide only. A CD-ROM (1993) is also available.
 - *Index muscorum* (1959 to date). Includes all names of mosses with basionyms, synonyms, and

references. Updated in the journal *Taxon*.

- GRETER, W., MCNEILL, J., BARRIE, F.R., BURDET, H.-M., DEMOULIN, V., FILGUERAS, T.S., NICOLSON, D.H., SILVA, P.C., SKOG, J.E. , TREHANE, P., TURLAND, N.J. & HAWKSWORTH, D.L. (eds) 2000. *International Code of Botanical Nomenclature* (Saint Louis Code). Koeltz Scientific Books. Konigstein, Germany. Rules and procedures for publishing new names.
- JACKSON, B.D. 1928. *A glossary of botanic terms*. 4th ed. Duckworth, London. Very useful to find definitions of botanical terms used in keys and descriptions.
- *Kew Record of Taxonomic Literature* (1971 to date). Regularly lists recent world literature on vascular plants.
- MABBERTLEY, D.J. 1997. *The plant book 2nd ed.* Cambridge University Press. A comprehensive small dictionary of flowering plants, conifers, and ferns.
- SMITH, G.F. & WILLIS C.K. 1999. Index herbariorum: southern African supplement. 2nd edn. SABONET Report No. 8. SABONET, Pretoria. A useful supplement to the international Index herbariorum; lists herbaria for the entire southern African region.
- STAFLEU, F.A. & COWAN, R.S. 1976–1988. *Taxonomic literature: a selective guide to botanical publications and collections with dates, commentaries, and types*. 2nd edn. Bohn, Scheltema & Holkema, Utrecht. Gives much information on authors, their publications, location of herbaria and types, ranging from 1753 to 1939.
- STEARN, W.T. 1992. *Botanical Latin: history, grammar, syntax, terminology, and vocabulary*. 4th ed. David & Charles, Newton Abbot, Devon. A dictionary of Latin with many drawings illustrating the terms.
- WILLIS, J.C. 1985. *A dictionary of the flowering plants and ferns*. 8th edn. Cambridge University Press, Cambridge. Gives names, authors, number of species, and geographical range of vascular plant genera. Also has descriptions and internal classification for family names.

Incorporating new research

It is important to keep the herbarium up to date with current research. Incorporating a revision means reorganising the specimens, files, and filing system according to the most recent publication. Assess all publications and determine whether they are acceptable, given the knowledge you may have of the group. If, on the other hand, you are not able to evaluate a revision effectively and publish a more acceptable account, it is best to incorporate the publication and accept the authority of the author. ▲

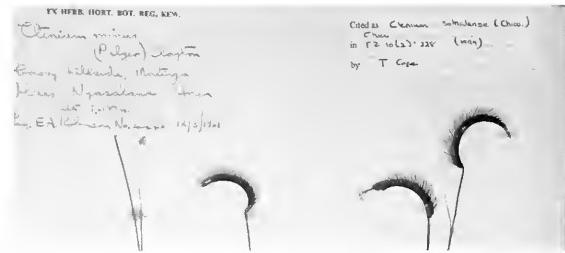
How to evaluate taxonomic revisions

The ability to evaluate a revision depends largely on experience with, and knowledge of the taxa concerned. The assessment of a revision should include the following steps:

1. Determine whether the author studied ample material from African herbaria, especially from your own collection.
2. If the author took loans from your herbarium, study all the specimens cited and identified by the author in order to form an idea of the species concept.
3. Evaluate the key by using it to identify cited material.
4. Examine the taxonomic limits of the taxa: are they clearly delimited from each other, or do they overlap? (For example, "leaves 5–10 cm" is not clearly delimited from "leaves 7–15 cm".)
5. Keep in mind that the author may be a "lumper" or a "splitter". A "lumper" sets rather wide margins for the taxa, hence joining several together as one. On the other hand, the "splitter" allows very small differences between taxa, thus retaining many species as distinct. (You will have your own idea of how much difference is "enough" between species. It may not coincide with the author's.)
6. Consult other herbaria as to their acceptance or rejection of the paper.
7. If the curator of a plant group does not accept a revision, they should write detailed notes justifying the decision. File the notes with the taxon.



To become acquainted with the newly revised genus, take cited material and work "backwards" through the key. This will enable you to become familiar with the terminology of the important character states.

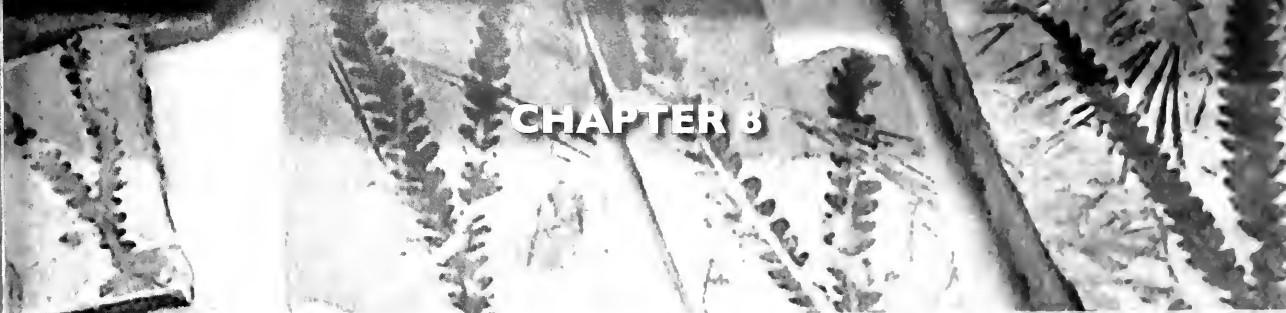


A specimen showing "Cited as..." label; it includes the plant name, publication reference, author, and date of publication.

How to incorporate a taxonomic revision

Once you have accepted a publication for incorporation, you can start reorganising the specimens and files in the herbarium.

1. Search the collection for cited material, looking at the existing species, *spp.*, and *aff.* species covers. Don't forget the Quick Guide.
2. Give such specimens each a *Cited as* label; include the plant name, publication reference, author, and date of publication. Duplicate material not actually seen by the author is labelled *e num.* or *ex num.* (*ex numero* = from the number).
3. Search the collection for type specimens, both for accepted taxa and for synonyms. Place them in type covers.
4. In the publication, a reprint or photocopies, mark the collector's name and number, thereby indicating that you have that specimen in your collection.
5. Where necessary, change filing numbers on specimens according to the new arrangement.
6. Re-identify all specimens not cited by the author.
7. Where formerly accepted taxa have been placed into synonymy, change the name on all the genus and species covers.
8. Re-file the specimens, rearranging the order of the files according to the publication.
9. Mount the publication on a mounting board and file this in a species cover marked *Notes* or *Literature* at the beginning of the genus or species concerned.
10. Update the cupboard list.
11. Update the computerised (specimen and taxonomic) databases.
12. Update the Quick Guide using authenticated specimens where possible.



CHAPTER 8

starting a new herbarium



*Do what you can,
with what you have,
where you are.*

— Theodore Roosevelt

When starting a new herbarium, it is useful to know what infrastructure, equipment, and supplies would be adequate for your needs. In this chapter, we provide guidelines for setting up and managing a new herbarium.

Purpose

The main purpose of a herbarium is ongoing taxonomic research. This research relies on a collection of preserved plants—the herbarium—that is built up over a long period. There are many different activities associated with building up and maintaining a herbarium collection.

Collecting, preserving and storing specimens

Collected specimens should be of a high quality and meticulously preserved. A standardised storing system should be used to ensure that specimens are easily retrievable. The arrangement of specimens could be based on a simple alphabetical system, or on a more complex system based on taxonomic relationships. A high standard of label information is also essential.

Identification

Identification is based on taxonomic relationships. It is the matching of unnamed plants with named specimens in the collections, based on similarities between the specimens.

Nomenclature

When naming plants, the focus is on maintaining nomenclatural standards. Names of specimens should be kept in line with any revisions done. A type collection must be maintained and exchanges of specimens with other institutions must be standard practice.

Comprehensive collection

The aim is to work towards a fully representative collection, representing the diversity and distribution of the region's vegetation. This implies undertaking collecting trips to under-collected areas and ensuring that all taxa in the region are represented.

Determining basic needs

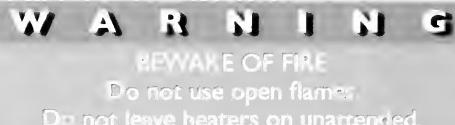
Once the purpose of the herbarium is clear, an inventory of basic needs can be compiled. This would include the estimated size of the herbarium, staffing, cupboard and working space, and equipment required such as microscopes, plant presses, freezers, microwave ovens, and good quality card of a standard size for mounting. The system for the arrangement of specimens should be decided from the start as this could affect the layout of the herbarium. (For more information on filing systems, see "Filing specimens").

Registering in *Index herbariorum*

The *Index herbariorum* (Holmgren *et al.* 1990) is a worldwide register of herbaria that provides concise information about a large number of herbaria. The staff of the New York Botanical Gardens maintains this useful publication. To be registered in *Index herbariorum*, a unique acronym (for example, GAB for the National Herbarium of Botswana, Gaborone) is needed, as well as information about the size, collections, staff, contact person, and address.

Infrastructure and functional areas

The building housing a new herbarium should be given careful thought before work commences. Work areas, storage space, and offices should be incorporated in the layout. In this section, we also discuss cupboards, lighting, ventilation, and many other aspects of an efficient herbarium.



Buildings

Buildings should preferably be custom-built and designed with the staff complement, as well as the size and layout of cupboards in mind. The layout should take into consideration whether or not the ancillary collections will be housed separately.

It is important that buildings are water and dust proof, and that pests can be controlled easily. A form of fire protection should be in place in every herbarium; this can be an automatic or manual system. Fire is potentially the most devastating disaster for a herbarium; care should be taken to follow international standards for fire protection. Be aware of possible flooding dangers, as this can also ruin the collection.



Working areas, storage space, and offices

Ideally, members of the herbarium staff should have their offices outside the main herbarium to allow for minimum disturbance.

There should be enough work surfaces inside the herbarium for researchers and other workers to spread out specimens when working with them.

A packaging area may be required for sending and receiving specimens, books, and so on. This area is best kept separate and suitably equipped with a large working surface, easy access to wrapping materials, and a scale.

A mounting area should also be kept separate from the main collections to reduce insect contamination and to consolidate mounting activities and equipment.

Storage space would depend on the quantity of supplies that are kept, but should be suitably shelved and maintained for optimum efficiency.



Specimens stacked in different types of cupboards—wooden (above) and metal (below).

Cupboards

Specimens are stacked on top of each other and stored in shelved cupboards. The cupboards are shelved with pigeon-holes that are a little wider than the standard mounting board, and deep enough to hold a moderate pile of specimens—not too many, otherwise the lower specimens could be damaged by the weight. Over the years, cupboards have had different designs; all cupboards should, however, comply with the following standards:

- Cupboards should ideally have shelves approximately 150 mm apart, with close-fitting doors to provide protection from insects and dust.
- Metal cupboards should have doors with magnetic sealing strips around the edges for the same reason.
- Wooden cupboards may not provide the same protection against insects, but in humid climates they are not subject to condensation to the same degree.
- In a fire, unless they catch alight, wooden cupboards may offer better protection to specimens, since metal may overheat and singe the contents.

Lighting

Studying herbarium specimens with microscopes and hand lenses requires good lighting. In sunny countries, large windows may leave plant specimens exposed and vulnerable to direct sunlight. To avoid damage to plant specimens, use of artificial or indirect light is preferable. In colder climates, however, most use is made of natural lighting; for example, the herbarium of the Royal Botanic Garden in Edinburgh (RBGE, Scotland, UK) is large and has windows on the one side and a light shaft in the centre. This makes the best of natural lighting, thereby reducing the amount of artificial light needed.

Ventilation

In some climates, atmosphere control by air conditioners and humidifiers is essential in a herbarium. Such control does, however, create an artificial working atmosphere for staff and is expensive to install and maintain. The decision to control the atmosphere should therefore be made with great care, taking into account the fumigation method used and compatibility with the fire protection system. In addition, ventilation should comply with Health & Safety standards.

Telecommunications

Telephones offer an effective way of communication, for example, faxing, as well as access to the Internet and e-mail through computers. Careful planning is needed to ensure that the telephone points are placed in practical positions. Computers have

become indispensable in modern herbaria as they are used in many aspects of herbarium work. They may have to be placed near a telephone jack if a modem is required for electronic communication.

Library

A library or access to a library is essential for herbarium staff. Although electronic literature searches are made easy through technology that is becoming more freely available, all herbaria should have at least the standard reference works. It is also important to keep all possible Floras for the region, and the most recent botanical works relevant to the area, or local families. (For more information on books, see "Recommended herbarium literature".)

Laboratory

It is convenient to have laboratory facilities in the herbarium for researchers. Depending on the researchers' needs, laboratories can be relatively simple or very well equipped. In all cases, it is useful to have basic facilities available: a workbench, scale, fume cabinet, glassware, and necessary chemicals. Other research facilities can be created (for example, for cytological work); these are often driven by individual preferences and the nature of the research.

The use of open flames and corrosive chemicals, such as acids, necessitate a fire protection system and a cold-water shower facility in case of an emergency. For the health and safety of staff, there must be a special storage cupboard or room for chemicals. Flammable substances, such as alcohol, should be stored away from the main building. It is also a good idea to have a first aid kit.



Specimens being dried in plant dryers.

Reception

A reception area for visitors is convenient. Some herbaria also have special working areas for visitors to control their access to the collections.

Specimen reception is separated from other herbarium collections to reduce insect contamination. Strict hygiene regulations should be followed and no new accessions should be allowed into the main collection, unless first decontaminated. It is best to have two separated spaces for working with incoming specimens: one for contaminated material (for example, specimens donated from other herbaria, or specimens being unpacked and sorted for drying after a field trip); the other for decontaminated plants, such as those being sorted for identification or mounting. For more information on insect contamination, see "Herbarium Pests".

Equipment and supplies

As far as possible all herbaria that keep their specimens as archival records, should avoid using material of a temporary nature, such as sticky tape, masking tape, magic tape, plastic packaging tape, and self-adhesive labels. It is best to use only archival materials, such as methylcellulose adhesive, archival ink pens, and acid-free paper.

Decontamination equipment

All new accessions and any insect-contaminated material need to be decontaminated. A freezer is the most essential piece of equipment; microwave ovens are very useful as well. Chemical methods used to be popular, but because of the potential health hazard, are not used much today. For more information on decontamination, see "Herbarium Pests".

Plant dryers

When choosing a plant dryer, take into account the number of specimens likely to be dried at one time. Many different kinds are available, ranging from a wooden box with a grid over a light bulb, to a walk-in oven; some advanced dryers even press and dry at the same time.

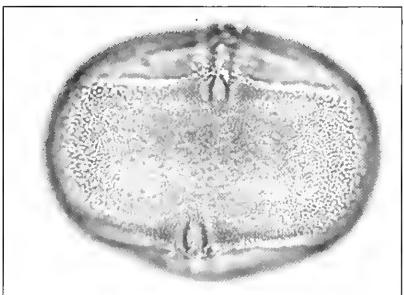
Magnifying instruments

Most identification keys make use of characters that need high magnification; therefore, magnifying instruments are essential in a herbarium.

- **Hand lenses** (8–10x) are very useful for observing characters on specimens in the field, as well as in the herbarium.
- **Stereomicroscopes** have magnifications higher than 20x and are used to observe micro-characters on specimens.



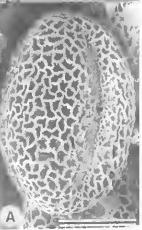
Hand lens being used to magnify grass spikelets.



Pollen grains viewed through a light microscope.



▲ Scanning electron microscope.
► A pollen grain viewed through this instrument.



- Transmission microscopes are often needed to observe special characters such as cell structure in water plants and bryophytes. Preparations on microscope slides are required.
- Microscope attachments, that is, a camera and drawing tube, are invaluable (in the illustration of research papers) to herbaria active in research.
- Electron microscopes, transmission and scanning, are used for specialist research.

Maps

Maps are essential for research and fieldwork. They are used for pinpointing localities, based on specimen label information and for supplying accurate locality data when new specimens are collected. Locality information, in turn, is used to establish the distribution range of a species.

Maps can be stored flat, folded, rolled, or hanging in special cabinets or drawers.

Preserve older and historic maps; they are often of great help when you are trying to find localities written on old specimens. This could, for example, be necessary when you are planning a field trip to collect a rare species, of which the only record is an old specimen with a locality name that is no longer in use. For more information, see "Maps".

Camera

A camera is useful for botanical photography, both in the field and in the herbarium, as well as for recording incidents in the history of your herbarium.

The best camera to get is a single-lens reflex (SLR) camera, preferably one with optional auto focus. An additional lens for macrophotography, for taking close-up images of flowers, for example, is also very useful.

Digital cameras are becoming more affordable and popular and are very useful for photographing people, plants, and landscapes in the field, since one can immediately see the result and delete unwanted images. Special adapters are available for using a digital camera with a microscope. Digital cameras, however, have some disadvantages:

- There are capital expenses related to downloading or reproducing the images (for example, software and printer); however, one saves on film, processing, and printing costs.
- The quality of the image produced by an affordable digital camera is inferior to that produced by an SLR camera, but this may change as advanced technology becomes increas-

ingly affordable.

- Macro-photography is not of a high standard, unless you buy an expensive model.

Other equipment

A herbarium also needs the usual office equipment, such as a photocopier, fax machine, telephone, and stationery. In addition, specialised equipment is necessary for collecting, mounting, preserving, and studying specimens. These are discussed in more detail in the other chapters of this book.

- **Plant collecting equipment.** See "Collecting Plants".
- **Mounting equipment.** See "Mounting Specimens".
- **Containers for spirit collection.** Plastic containers of different sizes to collect and store material in spirits. See "Spirit collection".
- **Packaging equipment.** For posting specimens or books: boxes, brown paper, packaging tape, string. See "Handling requests for loans".
- **Dissecting equipment.** See "Identifying specimens".

Herbarium services

A herbarium can offer a wide range of services, both to scientists and other professionals, and the public.

Information service

A herbarium is the most likely place to contact if members of the public want to make an enquiry regarding the name of a plant. An information service can be introduced to respond to enquiries from the public, to make botanical information more accessible, and to improve public relations.

A herbarium staff member should be able to answer enquiries relating to plant identity and plant names (common names, synonyms, and so on). It is useful to keep the following books in a place accessible from the telephone:

- A book on common names, such as that by Smith (1966) for South Africa, or Cole (1995) for Botswana.
- A book on names of plants, such as *The plant book* by Maberley (1997), which has a worldwide coverage.
- Also helpful is a reference on poisonous plants, such as that by Watt & Breyer-Brandwijk (1962).

It is essential to deal with enquiries in a friendly and efficient manner. However, many questions directed at herbarium staff members are about subjects for which they are not necessarily equipped, for example, queries about plant diseases, horticulture, and even solutions to crossword puzzle questions! Unless the staff member knows the answer to the query, it may be best

to refer the enquirer to someone with the relevant knowledge. A list of useful telephone numbers next to the telephone makes referrals easier. If you are unable to refer the caller, tell them that the query is outside the scope of the knowledge of a taxonomist, or the function of that particular herbarium.

Visitors

Visitors to herbaria are generally welcomed as they ensure contact with other institutions and can contribute positively to curatorial care. Some herbaria are open to visitors, either on a daily basis or by appointment. Visitors who have an interest in herbaria include

- Researchers
- Casual visitors
- Consultants
- Commercial business people

Some herbaria keep a visitors' book for recording visitors' information, their research interests, and reasons for the visit. The book provides a useful list of contacts for future communication, as well as a record of the use of the herbarium.

Herbaria often prescribe regulations for visitors on, for example, handling specimens, dealing with name changes, selecting loans, and so on. Visitors should always be informed about herbarium practices and should work under supervision.

Plant identifications

Researchers, members of the public, and people with specific interests such as vets, herbicide companies, and consultants doing vegetation surveys, may all approach the herbarium to have plants identified. Although identification is a basic essential service provided by herbaria, a fee may be charged to cover the costs of processing and time involved. This fee may be waived if the person is not in a hurry for names and donates good quality specimens to the herbarium. Clients who need plants identified urgently are often charged a higher fee. If a herbarium has the capacity and chooses to provide an identification service, it is advisable to have a policy stipulating the conditions and charges for providing the service.



Keep the telephone numbers of doctors and poison information centres next to the phone.
Ask callers to supply a sample of the plant material for correct identification.



A herbarium staff member identifying plants.

Loans

It is a generally accepted practice for a herbarium to lend specimens to another herbarium for use by qualified researchers, studying particular taxonomic groups or problems. Loans make it possible to

- Assemble a greater, more varied amount of material of a group than is possessed by any one herbarium, thus providing a better basis for revisions and monographs.
- Compare specimens directly with types and other authentic material.
- Have specimens annotated by the monographer or specialist.

Loans are usually made between institutions rather than from institutions to individuals, and arrangements should be made through the correct channels. All correspondence should be addressed to the curator of the museum or herbarium. Conditions of loans should be included with the correspondence.

For detailed information, see "Loans".

Environmental Impact Assessments

Staff members of herbaria may be approached to take part in Environmental Impact Assessments (EIAs). Taxonomists may be very useful to an EIA team, because they are competent in naming plant species and may therefore assist with compiling species lists for vegetation surveys. A herbarium worker is, however, not likely to be qualified to do full EIAs and should be wary of getting too involved in large projects requiring specialist ecological knowledge. If asked to participate in an EIA, a herbarium worker should make it quite clear what skills are offered. A tax-

onomist may assist in some or all of the following ways:

- Collecting voucher specimens from the area under study.
- Identifying these specimens and providing the names.
- Consulting the herbarium collection and compiling a list of species historically found in the area under investigation.
- Studying the literature to determine the rarity and extent of distribution of the species.
- Highlighting the occurrence of rare or endangered species that are found during the collecting trip, or while consulting herbarium records or literature.
- Assessing whether development would be harmful to the distribution of rare species.
- Providing recommendations on the conservation of rare species.

For this work a fee may be negotiated; it should cover all direct costs, as well as time spent on the project.

Herbarium management

Without active, hard-working, dedicated staff to record, research, and communicate the wealth of information contained in a herbarium, the collections are worthless.

The energy and enthusiasm of staff should be directed by management to reach specified outcomes.

Staff management

Staff are the biggest asset to any herbarium. Many opportunities for staff to develop their knowledge and skills exist in any herbarium. Managers and staff must continually explore ways of creating challenges for staff to grow.

Herbarium staff

Managers ensure that the herbarium functions effectively. The most senior manager of a herbarium can be a director, curator, or keeper.

Researchers generally research the flora covered by the herbarium. Their research is usually restricted to a small number of families, although they are also responsible for the quality of scientific curation. Researchers are often involved in larger collaborative projects.

Technicians are generally involved in the day-to-day activities of the herbarium, such as plant identifications and scientific curation. They are generally responsible for a large range of families. After retirement, many researchers continue their research and can contribute substantially in this way.

Supporting staff hold a wide range of positions. They can be dedicated to a specific position, or fulfil a variety of tasks including mounting, packaging, filing, preparing genus covers, and loan administration. They are often approached to help with specific tasks or to clear backlogs.

Financial management

Every herbarium has a budget, however small. Budgets are drawn up annually and should be managed to cover priority spending without over-spending. It is useful to have an itemised, yet flexible, budget to guide annual spending. Since priorities change continuously, a budget should be able to accommodate emergencies. ▲



Taxonomists on a plant collecting expedition press plants at their base camp.

APPENDIX I: HERBARIUM SUPPLIES

Local suppliers

The Pretoria National Herbarium (PRE) offers a non-profit herbarium supply service to smaller herbaria. PRE stocks most herbarium supplies, which are bought in bulk; some items are custom-made for the herbarium.

The following items are available to individuals and institutions:

- Plant presses (including straps)
- Single straps
- Drying paper (190 gsm, 450 x 280mm)
- Flimsies (unprinted newspaper, 550 x 420 mm)
- Genus covers (230 gsm, 570 x 430 mm)
- Species covers (230 gsm, 570 x 430 mm)
- Eltoro mounting boards (240 gsm, 270 x 420 mm)
- Acid-free mounting boards (300 gsm, 240 x 420 mm)
- Corrugated cardboard (280 x 450 mm)
- Field label notebooks
- Plastic zip bags (80 x 120 mm)
- Plastic zip bags (100 x 110 mm)
- White gummed paper (50 mm wide)
- Tarcroft paper
- Seed envelopes: small (45x 45 mm); medium (65 x 65 mm); large (90 x 90 mm)
- Raffia tails
- Boxes: size A (430 x 300 x 80 mm); size B (430 x 300 x 155 mm); size C (430 x 300 x 230 mm)
- Cardboard sheets (box inlets) (470 x 270 x 295 mm)
- Brown paper bags: sizes 35, 20, 12, 8, 4, 1

You can request a current price list by writing to

Herbarium Supplies
National Herbarium Pretoria
Private Bag X101
Pretoria
0001
South Africa

International suppliers

Herbarium Supply Company
3483 Edison Way
Menlo Park
CA 94025
USA

University Products
517 Main Street
PO Box 101
Holyoke
MA 01041-0101
USA



APPENDIX II: FIELD LABEL

Collector:		No.:		Date:						
Provisional name:										
Region:		Grid:		Alt:						
GPS		°	'	S	°	'	E			
Locality										
Biome	Forest	Fynbos	Grassland	Nama Karoo	Savanna	Succulent karoo	Thicket			
Vegetation type										
Habitat	mountain peak	mountain slope	hilltop	hill slope	ridge	cliff face	ravine/kloof/gorge			
	talus/scree	plateau	valley	floodplain	waterfall	river/stream bank	river/stream			
	dry streambed	donga/gulley/ditch	pan	depression	marsh	swamp	wetland			
	seepage	dune (desert)	dune (coastal)	estuary	littoral	lagoon	sea			
	lake	dam	pond	plain	other:					
Substrate	soil	stony soil	rocky soil	gravel	bare rock	in water	termite mound			
	bark	leaf	leaf litter	roots	other:					
Moisture regime	well-drained	seasonally waterlogged			free standing water	tidal	mist/fog			
	moist/damp	permanently waterlogged			running water	other:				
Soil type	gravel	sand	loam	black turf	humus	clay	salt/brack			
Lithology	sandstone	shale	granite	quartzite	calcrete	dolomite	dolerite			
Exposure	shade	partial shade		full sun	Slope	none	gentle			
Aspect	N	S	W	E	NE	NW	SE	SW	moderate	steep
Biotic effect	abandoned land	cultivated land			pasture	recently burned	garden	roadside		
	plantation	grazed	disturbed	none seen	other:					
Life form	tree	shrub	dwarf shrub	herb	graminoid	geophyte	epiphyte			
	climber	parasite	succulent	hydrophyte	bryophyte	lichen	scrambler			
	saprophyte	lithophyte	other:							
Plant features (underground parts, bark, leaves, flowers, fruit, seeds, aroma)										
Flowers:	present	absent	Fruit:	present	absent	Plant height:	m			
Notes (local abundance, phenology, pollinators, herbivory, economic & ethnobotanical factors, voucher specimen)										
Voucher:	photo	ecology	cytology	anatomy	seed	spirit				
Plant name:										
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Genspec:	/			Det.:	Date:			No. of labels:		

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About SABONET

This publication is a product of the Southern African Botanical Diversity Network (SABONET), a programme aimed at strengthening the level of botanical expertise, expanding and improving herbarium and botanic garden collections, and fostering closer collaborative links among botanists in the southern African subcontinent.

The main objective of SABONET is to develop a strong core of professional botanists, taxonomists, horticulturists, and plant diversity specialists within the ten countries of southern Africa (Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia, and Zimbabwe). This core group will be competent to inventory, monitor, evaluate, and conserve the botanical diversity of the region in the face of specific development challenges, and to respond to the technical and scientific needs of the Convention on Biological Diversity.

To enhance the human resource capacity and infrastructure available in the region, SABONET offers training courses, workshops, and collaborative expeditions in under-collected areas. The programme produces a newsletter, *SABONET News*, and a series of occasional publications, the Southern African Botanical Diversity Network Report Series, of which this publication is part.

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